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Performance of Asphalt Concrete Airport Pavements During Thaw Weakening Periods

A Field Study

Vincent C. Janoo and Richard L. Berg

April 1991

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Cover: Falling weight deflectometer on a runway.

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U.S. Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

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PREFACE

This report was prepared by Dr. Vincent Janoo and Dr. Richard Berg, Research Civil Engineers, Civil and Geotechnical Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. Funding for this research was provided by the U.S. Department of Transportation, Federal Aviation Administration, under Interagency Agreement DTFA-01-84-2-02038.

The authors thank Wendy Allen, Edwin Chamberlain and William Quinn for technically reviewing this report. Special thanks are expressed to Frederick Carver, Rodney Jacobson and John Bayer, Jr. for their assistance in conducting the computer data reduction. Thanks are also expressed to Christopher Berini and Richard Guyer for their assistance in conducting the FWD tests.

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Performance of Asphalt Concrete Airport Pavements During Thaw Weakening Periods

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VINCENT C. JANOO AND RICHARD L. BERG

INTRODUCTION

Airfield pavements are subjected to freezing in the winter and thawing in the spring. In the winter the load-carrying capacity of the pavement increases dramatically because of freezing of the pavement structure. In the spring, however, the pavement structure thaws and can become saturated with water from the melting ice lenses, thus reducing the strength of the base, subbase and subgrade.

In the Spring of 1986, CRREL conducted Falling Weight Deflectometer (FWD) measurements for the Federal Aviation Administration (FAA) at three airfields in Wisconsin. The airports were Central Wisconsin Airport in Mosinee, Outagamie County Airport in Appleton and Wittman Field in Oshkosh. In addition to FWD measurements, surface and subsurface pavement temperatures were measured at selected sites. Also, an attempt was made to collect pore pressure measurements at some of these sites using tensiometers.

The objective of the study was to determine the change in the load-bearing capacity of airfield pavement structures in a seasonal frost area during thaw weakening periods using the FWD. This report gives a general description of one airfield—Wittman Field, Oshkosh, where the pavement surface is mostly asphalt concrete—and its pavement structure; the FWD measurements are analyzed as well.

DESCRIPTION OF WITTMAN FIELD

Wittman Field Airport is located in Oshkosh, Wisconsin (Fig. 1). The FAA classification of the subgrade at the airfield is E-7; under the Unified Soil Classification System, an E-7 soil can be considered to be a CL, CH or CL-ML material. In terms of frost-susceptibility, it is considered to be in the F3 or F4 group (Berg 1974).

The original airfield—constructed in 1945—consisted of runways 9/27, 4/22 and 13/31. In 1963, runway 9/27 was extended, and it was again extended to its current length in 1967. Runway 18/36 was constructed in 1980 and extended in 1988. A plan of the airfield is shown in Figure 2. The information on the pavement structure presented in this report comes primarily from a pavement evaluation report on Wittman Field (Eckrose/Green Associates and Donahue & Associates, Inc. 1989). The structure of runway 18/36 is 254 mm of Portland Cement Concrete (PCC) over 229 mm of granular subbase. Runway 9/27 consists of 191–292 mm of Asphalt Concrete (AC) over 152–203 mm of gravel base over 165–495 mm of granular subbase. Runways 4/22 and 13/31 consist of 51 mm of AC over subgrade.

FIELD TESTING PROGRAM

Prior to conducting nondestructive testing, we instrumented the airfield with temperature and moisture sensors. The temperature sensors installed were copper–constantan thermocouples. The total length of each thermocouple assembly was 488 cm, and their spacing is given in Table 1. The temperature measurements were made periodically by airport personnel during the winter months and by CRREL personnel during the FWD testing period in the spring.

The daily maximum and minimum air temperatures at the airport between 1 December 1985 and 30 April 1986 are presented in Figure 3. These temperature measurements were used to determine the air freezing

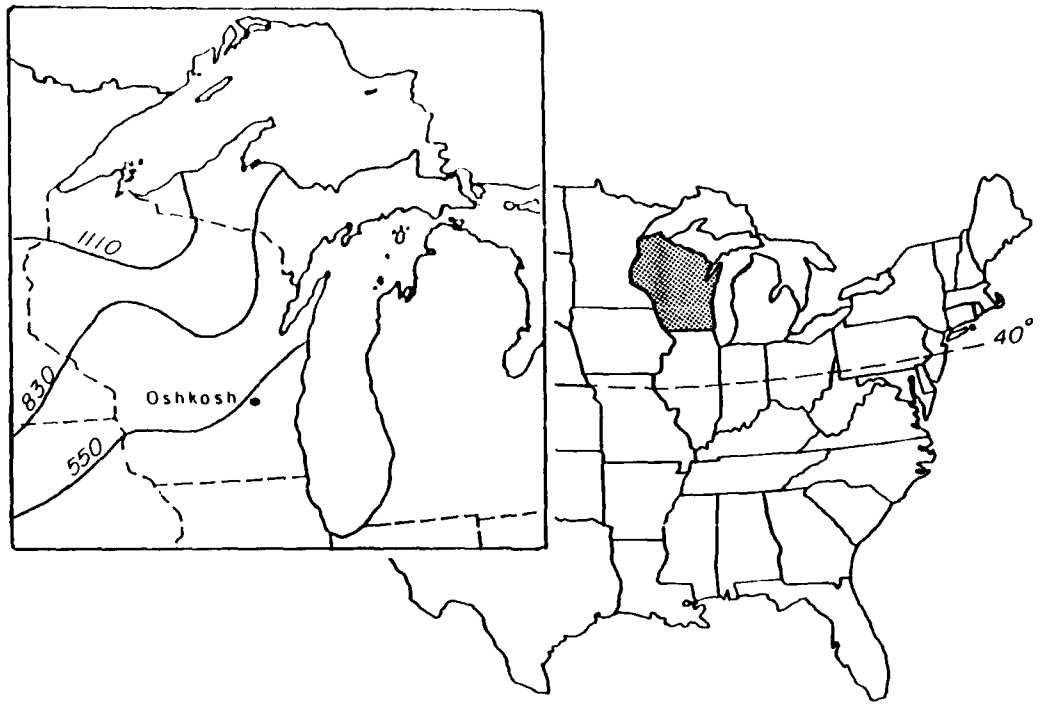


Figure 1. Location of Wittman Field (isolines show mean air freezing index [°C-days]).

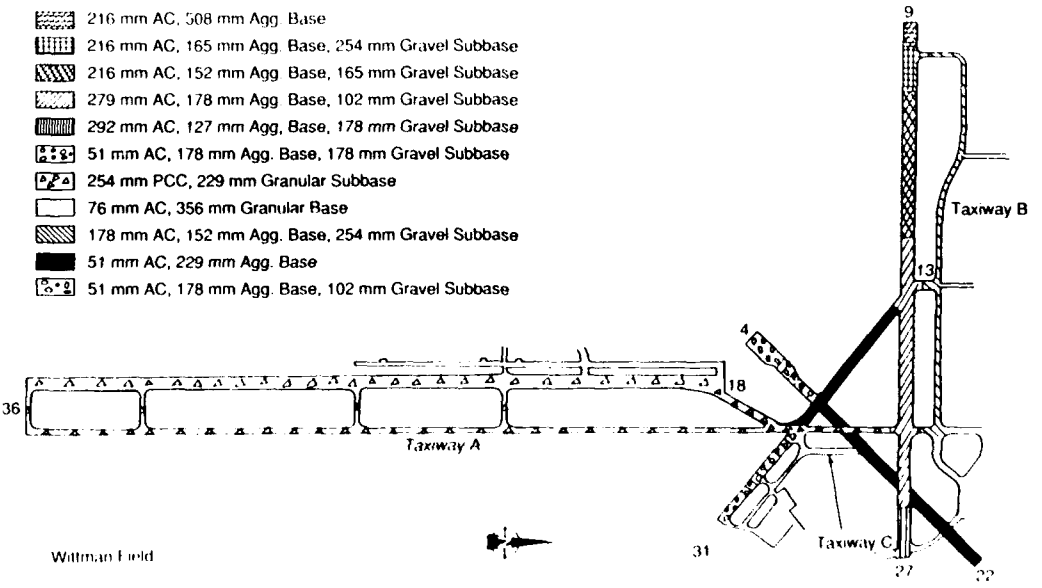


Figure 2. Pavement structure at Wittman Field.

Table 1. Temperature sensor locations under pavement surface.

Sensor	*Depth (cm)*
1	30.5
2	45.7
3	61.0
4	91.4
5	121.9
6	152.4
7	182.9
8	213.4
9	243.8
10	304.8
11	365.8
12	487.7

index (Fig. 4). The air freezing index was calculated in Celsius degree-days using

$$\text{Air Freezing Index} = \sum_{1}^{n} \frac{1}{2} (T_{max} + T_{min})$$

where T_{max} = daily maximum temperature (°C)
T_{min} = daily minimum temperature (°C).

The 1985–1986 air freezing index at Oshkosh was 900°C-days. This high index suggest a colder winter than normal, as the mean air freezing index for the area is 550°C-days (Berg and Johnson 1983). The freezing period ended as indicated in Figure 4, around 23 March 1986.

In the spring of 1986, nondestructive Dynatest 8000 FWD tests were conducted at selected sites at the airport. The FWD applies an impulse load to a pavement and the corresponding deflection of the pavement is measured by seven geophones. The FWD used is shown in Figure 5. The load level ranges from 7 to 120 kN and is applied for 25 to 30 ms. The seven geophones were located at 0, 300, 600, 900, 1200, 1500 and 1800 mm from the center of the loading plate.

The FWD test sites covered a large area of the airport and included both AC and PCC pavements. The FWD test program consisted of one drop at four height levels, producing loads of 600, 900, 1100 and 1600 kN on the pavement surface. The FWD deflection analysis presented in this report is for the 1600-kN load level. The deflection measurements for all load levels for the airport are presented in Appendix A.

The results obtained from the PCC pavements were not analyzed. The FWD results from the AC will be analyzed in terms of deflection basin area, Impulse Stiffness Modulus (ISM) and fourth sensor from the center plate deflections. The basin area for a seven deflection sensor system is calculated using the following formula

$$\text{Basin Area} = \sum_{i=1}^{6} \frac{1}{2} (d_i + d_{i+1}) (s_{i+1} - s_1)$$

where d_i = deflection at sensor i
s_i = sensor i distance from center of loading plate.

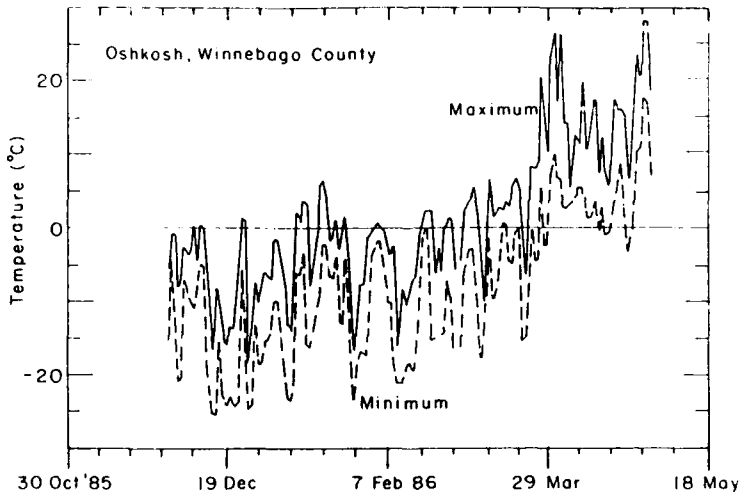


Figure 3. Daily minimum and maximum air temperatures at Wittman Field.

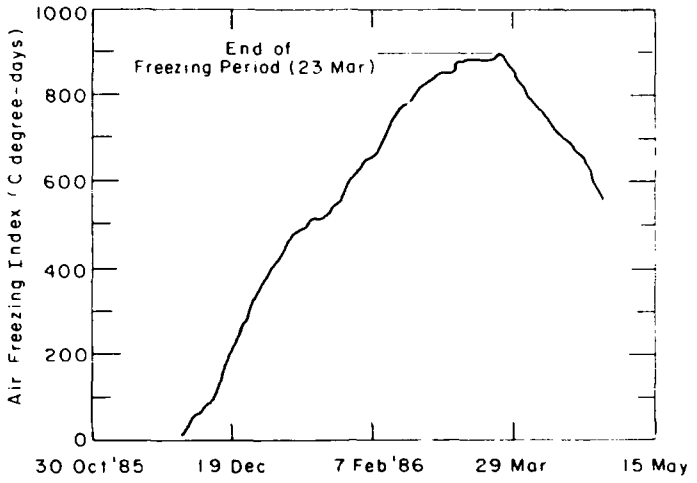


Figure 4. Air freezing index for Wittman Field.

The basin area has been found to be a good indicator of pavement response during thaw periods under controlled conditions (Janoo and Berg 1990). This concept will be validated here using the FWD measurements obtained from the three airfields.

A measure commonly used by the Corps of Engineers for characterizing pavement structures is the ISM. The ISM is analogous to the spring constant (k) of a spring mass system. The ISM is calculated from

$$\text{ISM} = \frac{\text{applied FWD load}}{\text{deflection under loading plate } (d_1)}$$

However, tests under controlled conditions have found the ISM to be insensitive to structural changes during the thaw period. This finding will be validated here with the field data.

The deflection measured at the fourth sensor from the center plate has been found to be a good indicator of the subgrade response during thawing periods (Janoo and Berg 1990). The fourth sensor was 900 mm from the center of the loading plate. The fourth sensor approach will also be validated here.

Figure 6 shows the FWD test points and where the temperature assemblies (TC1 and TC2) were installed

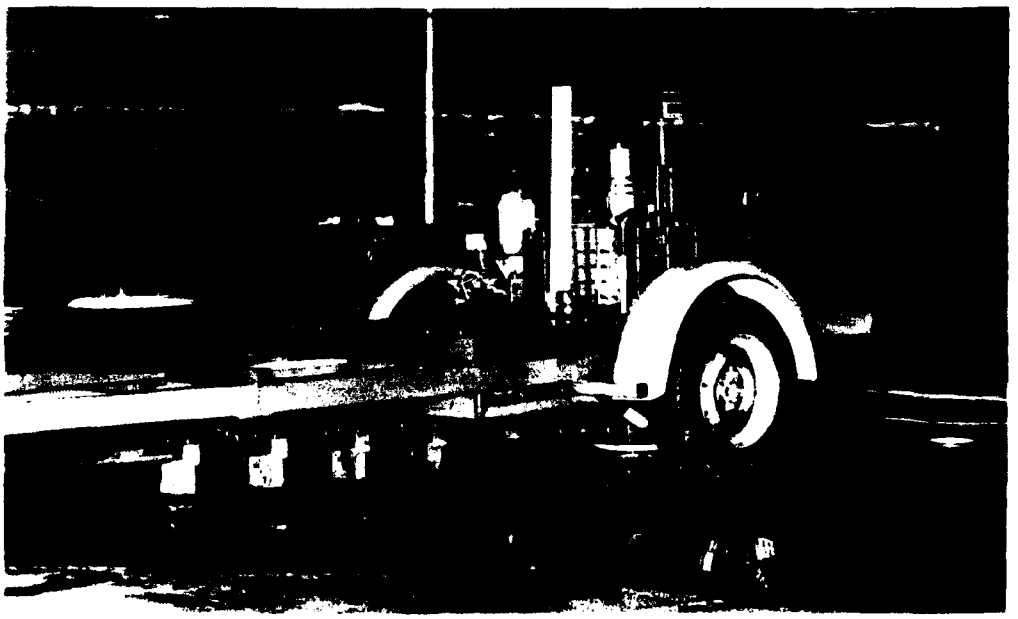


Figure 5. Dynatest 8000 series FWD.

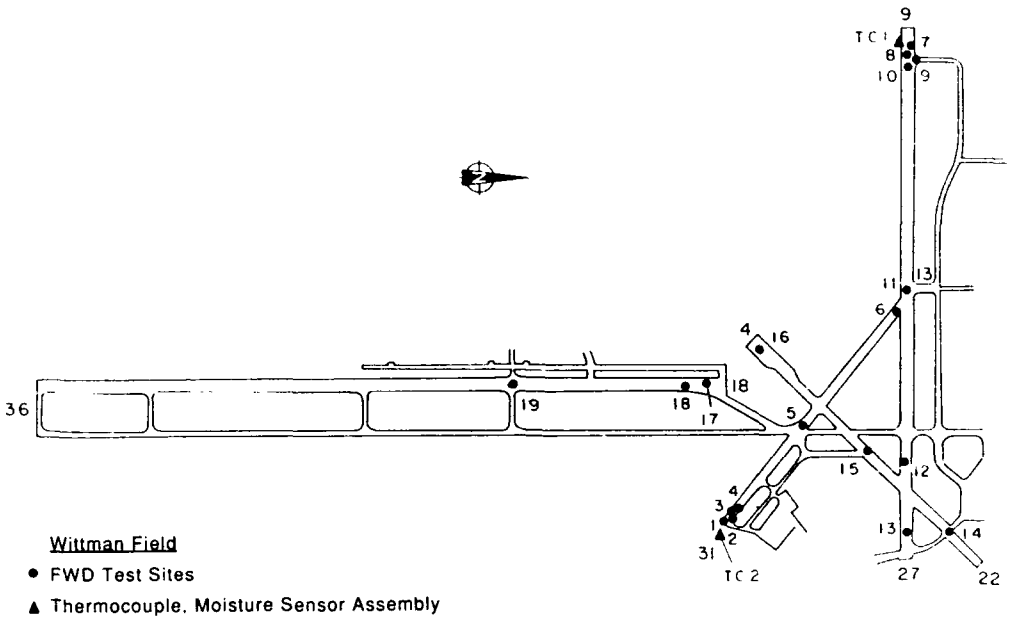
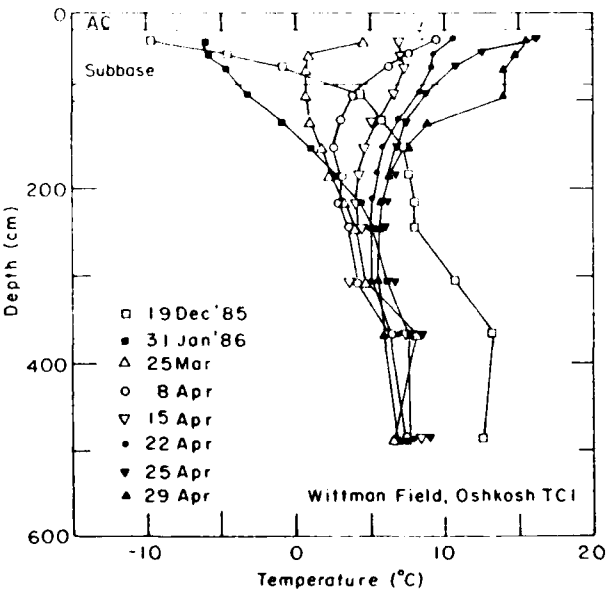


Figure 6. FWD, temperature and moisture sensor locations at Wittman Field.

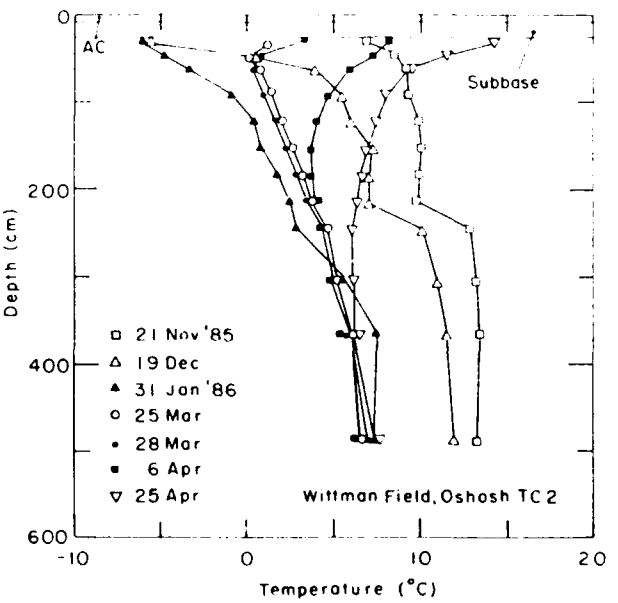
at Wittman Field. With the exception of test points 17, 18 and 19, all of the test points are on AC pavements.

Using the temperature measurements gathered from TC 1 and TC 2, we determined the frost depth. The frost or thaw depth was assumed to be where the soil temperature was 0°C. The ground temperature profiles through time at Wittman Field are presented in Figure 7. On 31 January 1986, the frost penetration depth at the airfield ranged between 120 and 140 cm.

Unfortunately, the subsurface temperature sensors were not functional between 1 February and 25 March 1986 because water that had flowed into the manhole during a mid-winter rain froze. The cables and sensor switches were encased in a large "ice cube" during this period.



a. TC1, runway 27/9.



b. TC2, runway 13/31.

Figure 7. Subsurface temperature profiles.

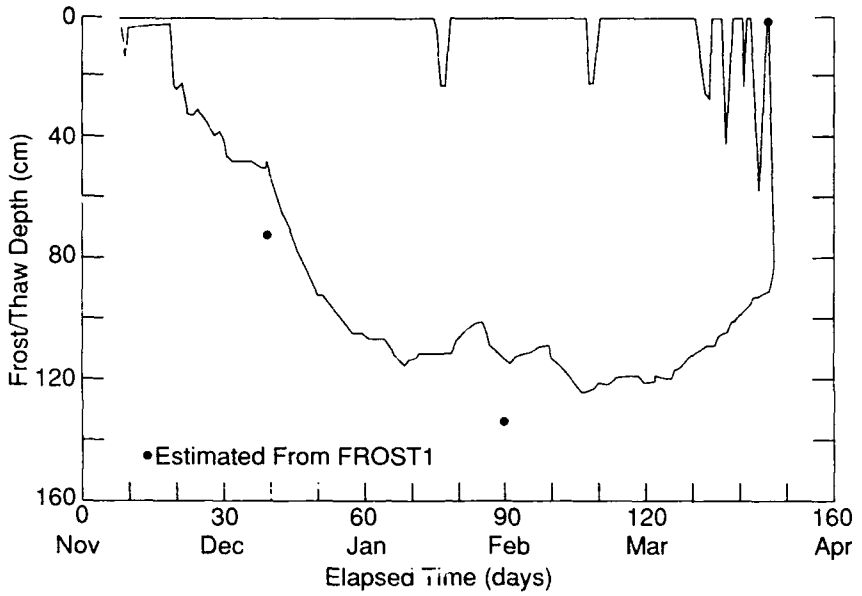


Figure 8. Maximum frost and time to thaw obtained from CRREL model FROST1.

Since measured subsurface temperatures were unavailable, we used the CRREL coupled heat and moisture flow (FROSTI) model to estimate the subsurface thermal regime. Figure 8 shows the computed frozen and thaw depths with time. The pavement profile used in the simulation is shown in Figure 9. The air temperatures shown in Figure 3 were also used. The frost depths obtained from Figure 7 were plotted on Figure 8 for comparison; as can be seen, the two are quite similar.

The total frost penetration can be approximated using the Schweizerische Normenvereinigung procedure (Ullidtz 1987)

$$D_f = 45\, I_g^{0.5} + (0.5\, t)$$

where D_f = frost penetration in millimeters
I_g = freezing index value (°C-days)
t = pavement structure thickness above subgrade in millimeters.

This equation is considered to be valid for frost-susceptible silt or clay subgrades with moisture contents in the range of 18–25% and a dry density of 1.6 g/cm^3 (F3 and F4 soils).

The estimated frost penetration from the above equation on runway 9/27 using the pavement structure in Figure 9 is about 180 cm. This estimate appears to be reasonable as frost depth measurements at nearby Central Wisconsin Airport for past years averaged approximately 190 cm (Stark and Berg 1989).

At the beginning of FWD testing (16 March 1986), ground temperatures were not measured. When ground temperatures were measured, beginning on 25 March 1986, the pavement structure and subgrade, based on the subsurface temperature profile (Fig. 7), had no frozen layers. However, whether the base, subbase and subgrade were drained or undrained is difficult to say. An attempt was made to quantify the moisture condition at these sites using tensiometers was abandoned because it was difficult to make any sense of the data.

The analysis of AC sections will be subdivided into two categories based on pavement structure (full depth vs conventional). One will consist of runway 9/27, and the other runways 13/31 and 4/22.

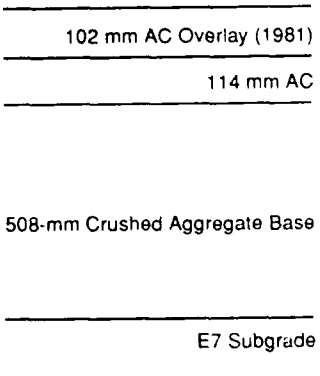


Figure 9. Pavement structure at FWD points 7–10.

Table 2. Location of FWD points 7–13 on runway 9/27.

FWD points	*Station*	*Position from pavement center line*
7	197+27	259 cm on left.
8	198+12	274 cm on right.
9	198+28	213 cm on left.
10	199+27	259 cm on right.
11	a	259 cm on right.
12	b	1 m on right.
13	c	244 m on left.

a 7.1 m from runway 13 end.
b 5.4 m from north–south taxiway.
c 8.7 m from runway 27 end.

Runway 9/27

As seen in Figure 6, FWD points 7–10 are located near the west end of runway 9/27, point 11 is midway on runway 9/27 and points 12 and 13 are near the east end. The locations are tabulated in Table 2.

The pavement structure that we used for this study for FWD locations 7–10 is shown in Figure 9. When FWD test results are used in a back-calculation analysis, it should be standard practice to core at the site to validate reported pavements structures. Through the course of this study, we found that the pavement structures reported in various references were different. After some consultation with the Wisconsin Department of Transportation, Bureau of Aeronautics,* we decided to use the pavement structures described in a pavement strength survey commissioned by the FAA (WDOT 1975). The AC overlay information used after 1975 was from Eckrose/Green Associates and Donahue & Associates, Inc. (1989). FWD locations 7–10 will be referred to as TP1.

*Personal communication with J.A. Jensen.

The pavement structure at locations 11 and 12 is shown in Figure 10 and at location 13 in Figure 11. Again, we used the structure from the FAA pavement strength study (WDOT), and the overlay information came from Eckrose/Green Associates and Donahue & Associates, Inc. (1989).

The changes in deflection basin areas with time at FWD locations 7–10 and FWD points 11–13 are shown in Figure 12. Scrivner et al. (1969) divided the annual strength history of pavement structures subjected to freeze–thaw cycling into four periods (Fig. 13). The critical period is defined as the time when the pavement undergoes a rapid strength loss followed by a rapid strength increase. Unlike Scrivner et al., our data (Fig. 12) show that the change in the basin areas can be divided into two segments. One segment is the critical period and the other the recovery period.

No FWD measurements were made between 28 March and 6 April 1986 because of mechanical problems with the FWD. As seen in the deflection basin area, this was probably the time when the pavement structure was at its weakest.

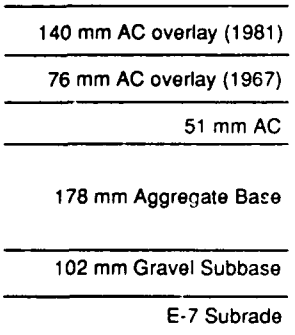


Figure 10. Pavement structure at FWD points 11 and 12.

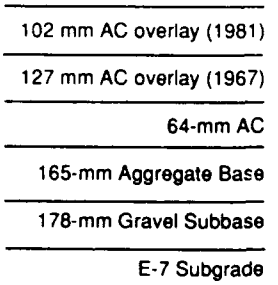
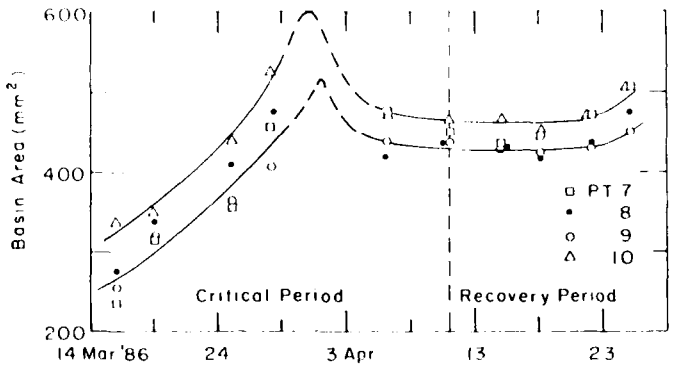


Figure 11. Pavement structure at FWD point 13.

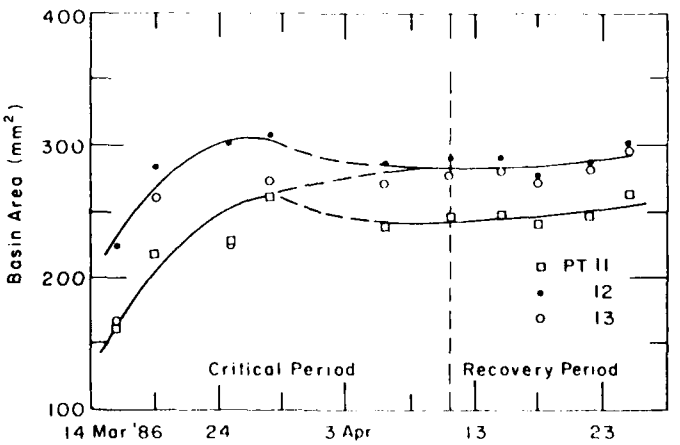
Figure 12 seems to show that, at the time when FWD measurements were started, the pavement structure was already in the the critical period of rapid strength loss. This is before the end of freezing as reported by the freezing index (22 March 1986). Our data show that the pavement strength recovery started after April 6. A similar observation was made with the fourth sensor deflection measurements (Fig. 14). The response at point 13 was different from those at points 11 and 12, probably because of the difference in pavement structure.

It is clear from the deflection basin area and fourth sensor deflection measurements (Fig. 12 and 14), that the pavement structure weakened during the spring thaw. However, the magnitude of weakening probably varied by a factor of approximately 1.5 between the two sections. The difference could be associated with the different pavement structures; however, other factors, such as the quality of the base and subbase may also be involved.

The trend in the ISM versus time plots in Figure 15 shows that there is a rapid change in ISM during the



a. FWD points 7–10.



b. FWD points 11–13.

Figure 12. Change in deflection basin areas during thaw on runway 9/27.

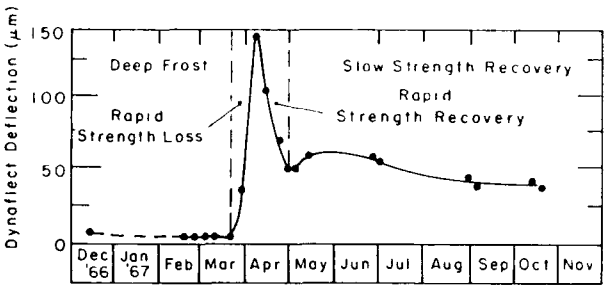
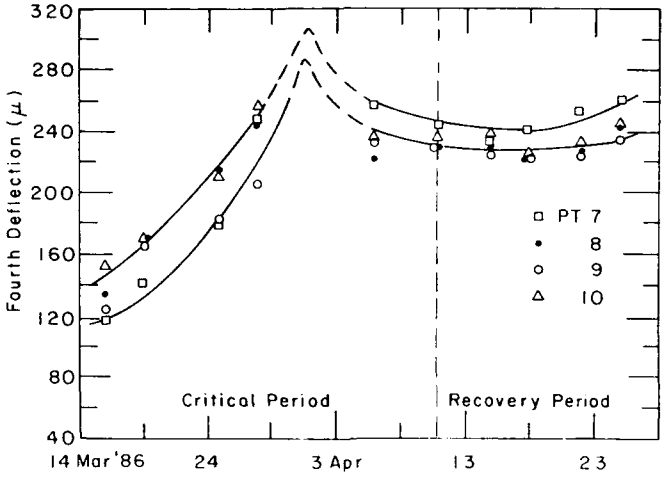
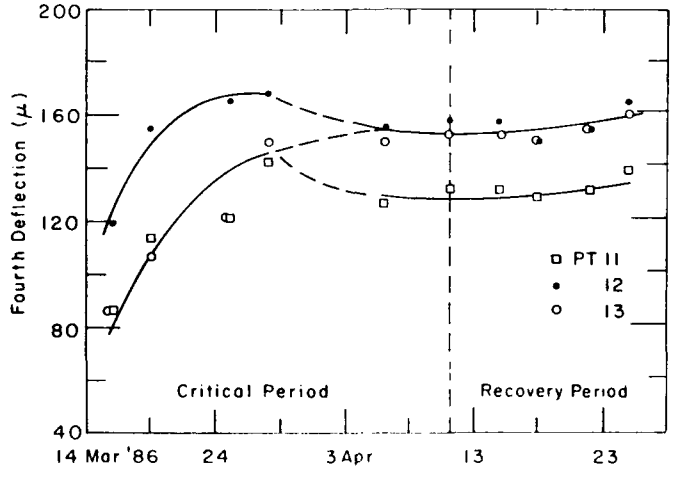


Figure 13. Typical seasonal variation in depth of deflection basin (after Scrivner 1969).

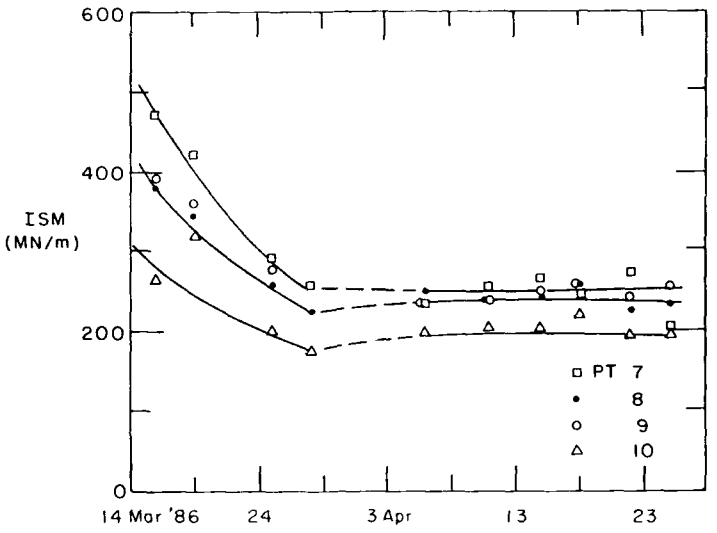


a. FWD points 7–10.

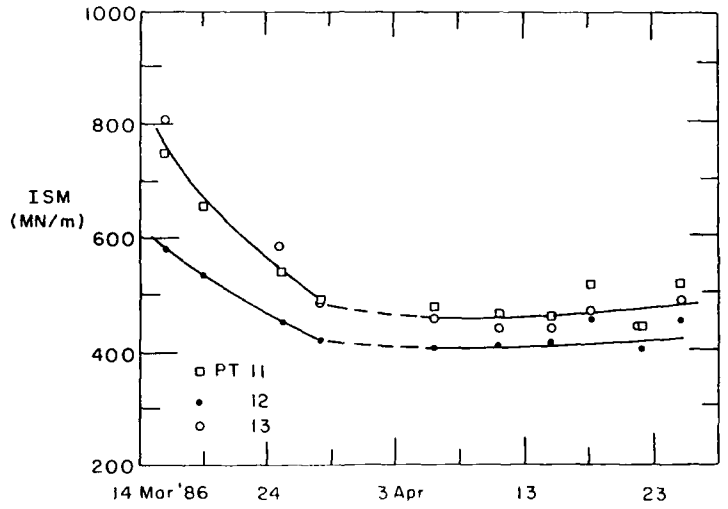


b. FWD points 11–13.

Figure 14. Change in the fourth sensor deflections during thaw on runway 9/27.



a. FWD points 7–10.



b. FWD points 11–13.

Figure 15. Change in impulse stiffness modulus (ISM) during thaw on runway 9/27.

initial phase of the critical period. However, no changes were seen during the recovery period. The above observations are similar to that reported in a controlled study in CRREL's Frost Effects Research Facility (FERF) (Janoo and Berg 1990).

Runways 13/31 and 4/22

There were six FWD points (1–6) on runway 13/31 and three points (14–16) on runway 4/22. Their locations are shown in Figure 6 and tabulated in Table 3. The pavement structures at the FWD points on runway 13/31 and 4/22 are shown in Figure 16.

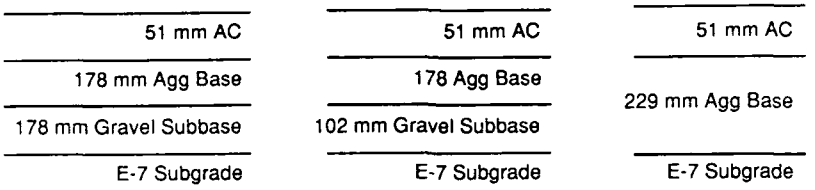
The trend in the deflection basin area and fourth sensor deflection measurements with time are shown in Figures 17 and 18. The shapes of the basin area curve with time are similar to one another, with the possible exception of point 1. A similar rate of change was seen at points 15 and 16 on runway 4/22. Point 1 showed a more gradual change. Point 6, on runway 13/31, and point 14, on runway 4/22, showed the largest change in basin area with time. A similar response was seen with the fourth sensor deflection measurements for these two points.

The difference in the pavement structure can be seen

Table 3. Location of FWD points 1–6 and 14–16 on runway 13/31.

FWD points	*Station*	*Position from pavement center line*
1	100+15	274 cm on left.
2	101+00	213 cm on right.
3	101+15	229 cm on left.
4	102+00	274 cm on right.
5	115+15	137 cm on left.
6	[a]	198 cm on left.
14	[b]	290 cm on left.
15	[c]	229 cm on right.
16	[d]	335 cm on left.

[a] Point 6 is 358 m from intersection with runway 4/22 and 132 m from intersection with runway 9/27.
[b] Point 14 was 27 m west of threshold and 113 m west of EOP.
[c] Point 15 was 256 m to centerline of runway 13/31.
[d] Point 16 was 271 m from centerline of runway 13/31 towards runway 4 end.

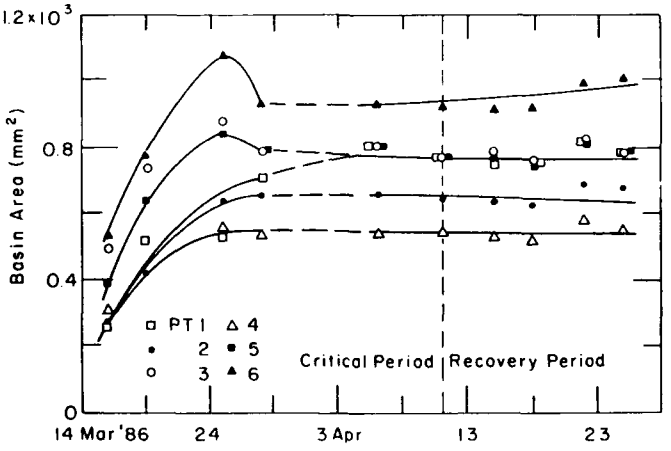


a. FWD points 1–4 on runway 13/31 and 16 on runway 4/22.

b. FWD point 5 on runway 13/31.

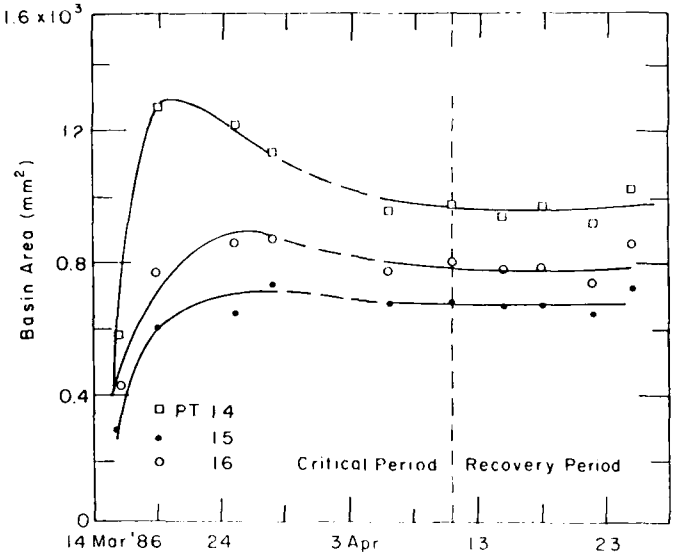
c. FWD point 6 on runway 13/31 and 14 and 15 on runway 4/22.

Figure 16. Pavement structure at FWD points on runway 13/31 and runway 4/22.



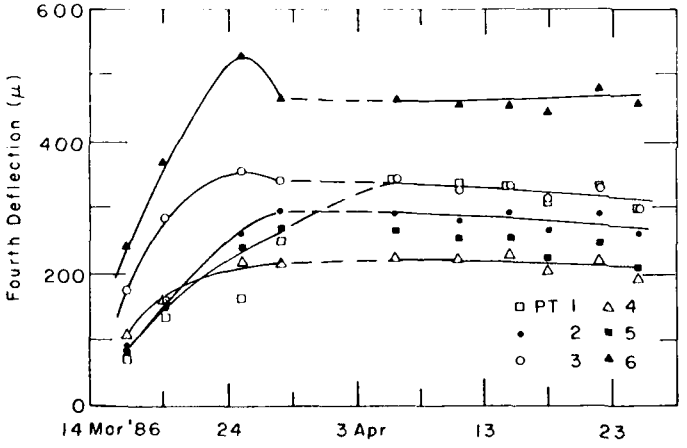
a. FWD points 1–6, runway 13/31.

Figure 17. Change in deflection basin area during thaw on runways 13/31 and 4/22.

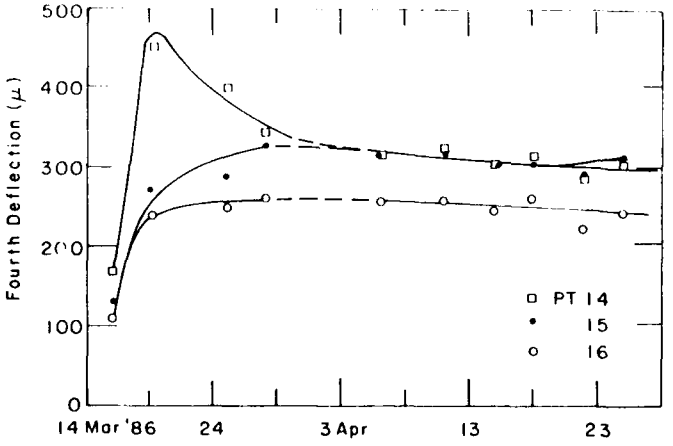


b. FWD points 14–16, runway 4/22.

Figure 17 (cont'd). Change in deflection basin area during thaw on runways 13/31 and 4/22.

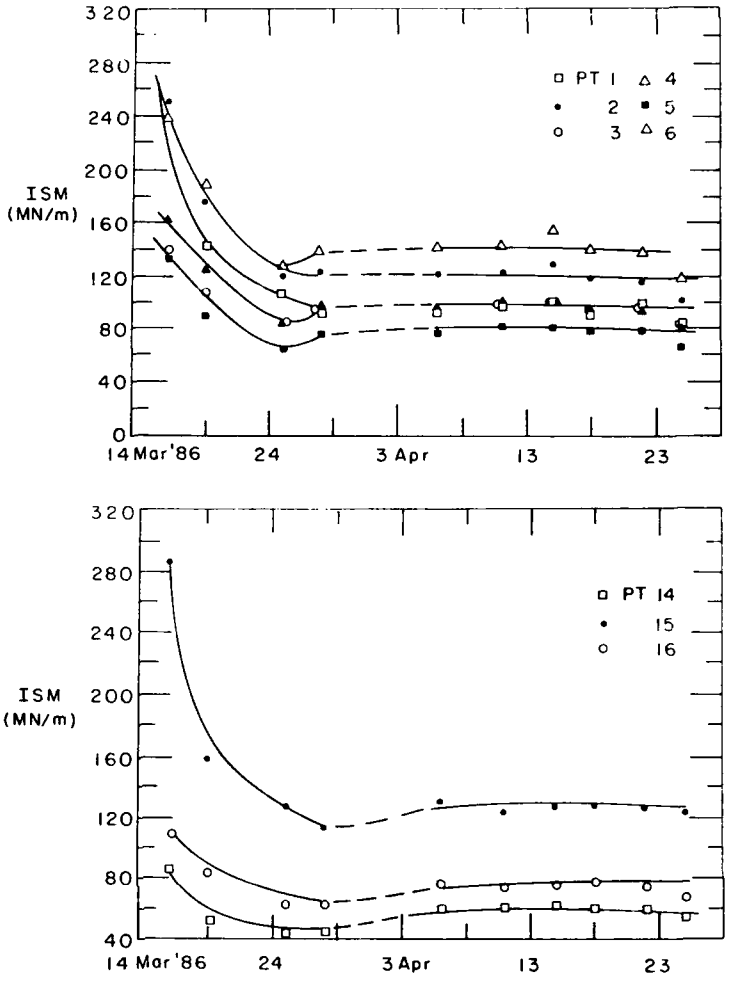


a. FWD points 1–6, runway 13/31.



b. FWD points 14–16, runway 4/22.

Figure 18. Change in the fourth sensor deflections during thaw on runways 13/31 and 4/22.



a. FWD points 1–6, runway 13/31.

b. FWD points 14–16, runway 4/22.

Figure 19. Change in impulse stiffness modulus (ISM) during thaw on runways 13/31 and 4/22.

to influence the deflection basin area or fourth sensor deflection when comparing runways 9/27 and 13/31 and 4/22. The magnitude of the basin areas on the average were twice as large.

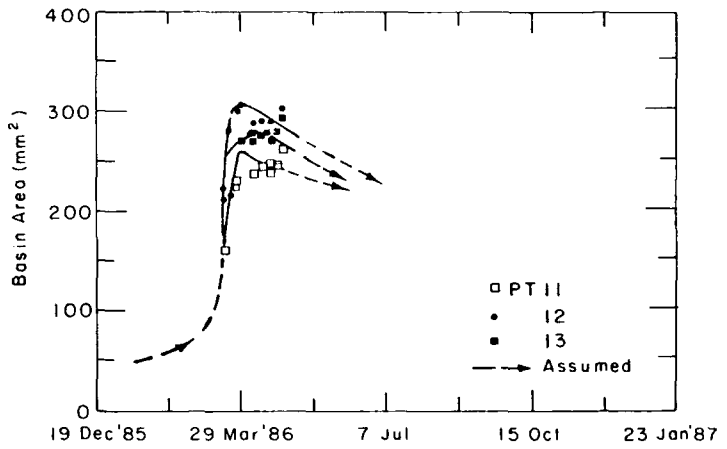
The response of ISM with time for runways 13/31 and 4/22 is shown in Figure 19. There appears to be a small change in ISM in some cases during the recovery period.

Summary of findings

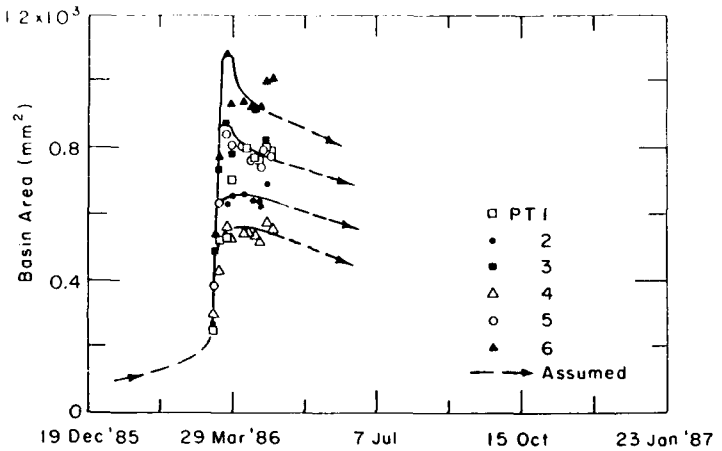
Scrivner et al. (1969) made deflection measurements to characterize pavement structures during the four seasons; two of the areas that they looked at were in Rochester and Duluth, Minnesota, where the mean air freezing indices were 720 and 1110°C-days respectively. These compare well with the air freezing index at Oshkosh (Fig. 4), which was 900°C-days during the winter of 1985–1986.

The critical periods reported by Scrivner et al. (1969) at Rochester and Duluth started about mid-March and lasted for 40 to 45 days respectively. The critical period observed at Wittman Field was at least 30 days. The subgrade at all three sites ranged between a silty clay and silty loam clay, fitting the FAA E-7 subgrade classification. Scrivner et al. (1969) found that the critical period was independent of the mean freezing index, suggesting that it probably depends on the drainage conditions in the pavement structure and the hydraulic conductivity of the subgrade.

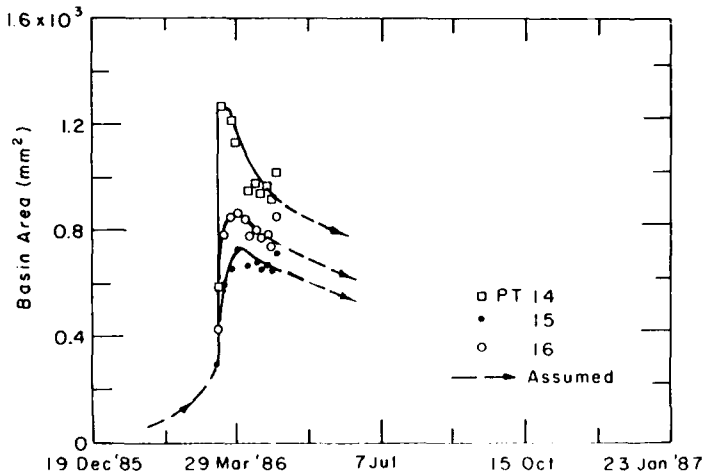
The deflection basin area data obtained at some of the FWD points during the spring thaw period are plotted with respect to a 1-year cycle in Figure 20. When we do this, it becomes apparent that to characterize the pavement response during the thaw weakening periods we need to know how the pavement responds during other times of the year. For example, if one only looks at the basin area during the spring thaw period, then one



a. FWD points 11–13, runway 9/27.



b. FWD points 1–6, runway 13/31.



c. FWD points 14–16, runway 4/22.

Figure 20. Assumed seasonal deflection basin area changes.

could conclude that the pavement structure has recovered in early April. However, the big picture (Fig. 20) shows that the pavement is still in the critical recovery period.

BACK-CALCULATION OF LAYER MODULUS

Two methods were used to back-calculate the elastic modulus of the pavement layers at several of the FWD points. One method was the simple one-layer elastic equation (Ahlvin and Ulery 1962). The second procedure used was the Corps of Engineers computer program WESDEF (Van Cauwelaert et al. 1989).

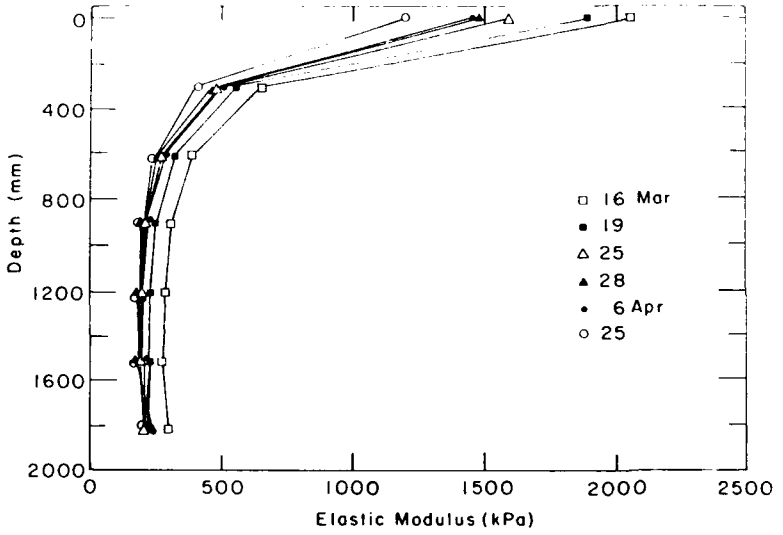
One layer elastic theory

The one layer elastic equation used to back-calculate the elastic modulus (E_i) is

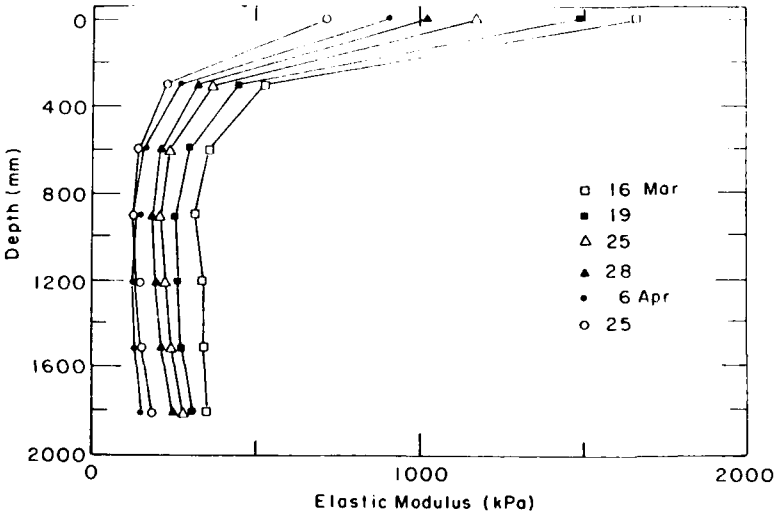
$$E_i = \frac{p\,(1+\mu)\,(1-\mu)\,H}{\delta_i}$$

where p = applied stress
μ = Poisson's ratio
δ_i = deflection at radial distance *(i)*
H = function developed by Ahlvin and Ulery (1962).

In the above equation, H is a function of radial distance and depth from the center of the applied load. If the depth is set to zero, then the radial surface deflections can be computed from the equation. In a similar fashion, if the surface deflections are known, the elastic or surface modulus can be determined. The change in the surface modulus with time and depth for four test points (7 and 12 on runway 9/27, 4 on runway 13/31 and 14 on runway 4/22) are shown in Figure 21. Ullidtz (1987)

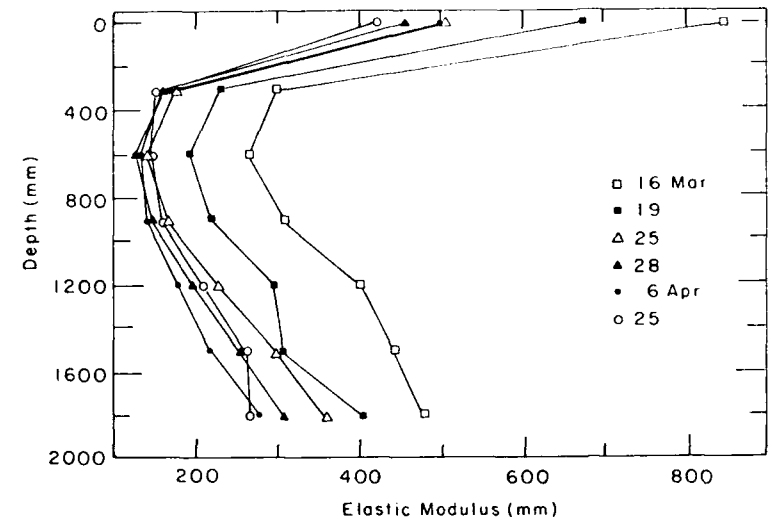


a. FWD point 12, runway 9/27.

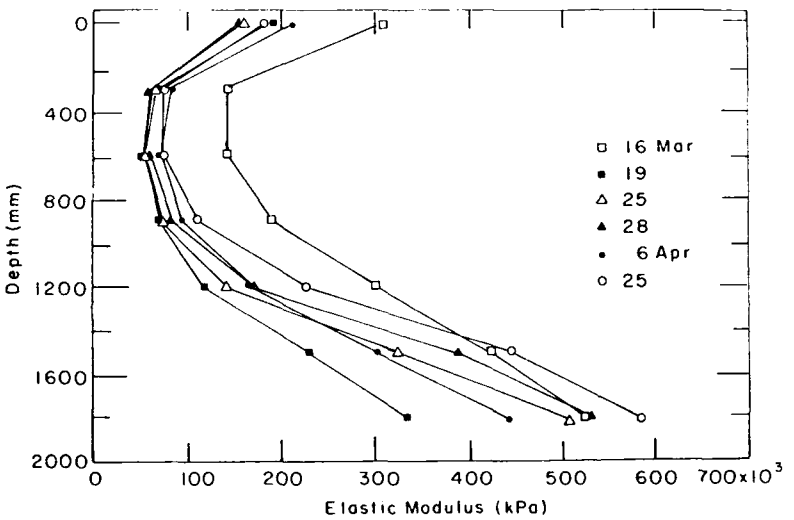


b. FWD point 7, runway 9/27.

Figure 21. Change in elastic modulus with depth determined using the modified Boussinesq solution.



c. FWD point 4, runway 13/31.



d. FWD point 14, runway 4/22.

Figure 21 (cont'd). Change in elastic modulus with depth determined using the modified Boussinesq solution.

used the surface modulus concept to characterize the subgrade as either behaving as a linear or nonlinear material. He assumed that the surface modulus calculated from the deflection measurements obtained at a radial distance (r) reflected the modulus at a depth $z = r$. The same assumption was used to plot Figure 21.

The above assumption is based on the idea that a large portion of the measured surface deflection is caused by the deflection of the subgrade, as is the case during spring thaw (Janoo and Berg 1990, Ullidtz 1987); then, the above equation should provide reasonable estimates of the subgrade modulus. Using similar figures as shown above, Ullidtz (1987), as mentioned earlier, characterized the subgrade as either behaving as a linear or nonlinear material. For example, Figures 21a and b would be characterized as representing a linear subgrade response, whereas Figures 21c and d represent a highly nonlinear subgrade response.

The estimate of the subgrade modulus can be used as a seed modulus in more rigorous back-calculation procedures. Where the subgrade shows a nonlinear response, the subgrade could be subdivided to account for the nonlinearity.

Further study of Figure 21 suggests that the concept of surface modulus might be used to delineate between frozen or thawed layers in the subgrade. An illustration of this is shown in Figure 22. The soundness of this suggested approach of locating frozen and thawed layers needs to be determined from additional field data.

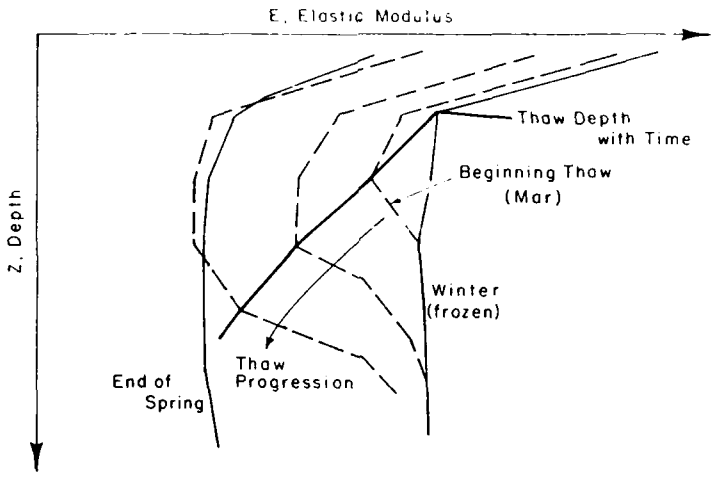


Figure 22. Locating thaw depth with time using surface modulus.

Layered elastic theory (WESDEF)

WESDEF uses the measured deflection basin from nondestructive testing to calculate the elastic moduli of pavement layers. This is accomplished by an iterative procedure to provide the best fit between measured and calculated deflection basins. The calculated deflection basins are obtained from layered elastic theory. WESDEF can handle up to four elastic layers and a rigid layer. A good match is obtained if the number of unknown layers is limited to three, a best fit when the Absolute Arithmetic (AA) error sum between the calculated and measured deflections is less than 10%. The results obtained from WESDEF and another pavement analysis computer program called BISDEF compare well; however, WESDEF's execution time is 4.5 times faster than that of BISDEF.

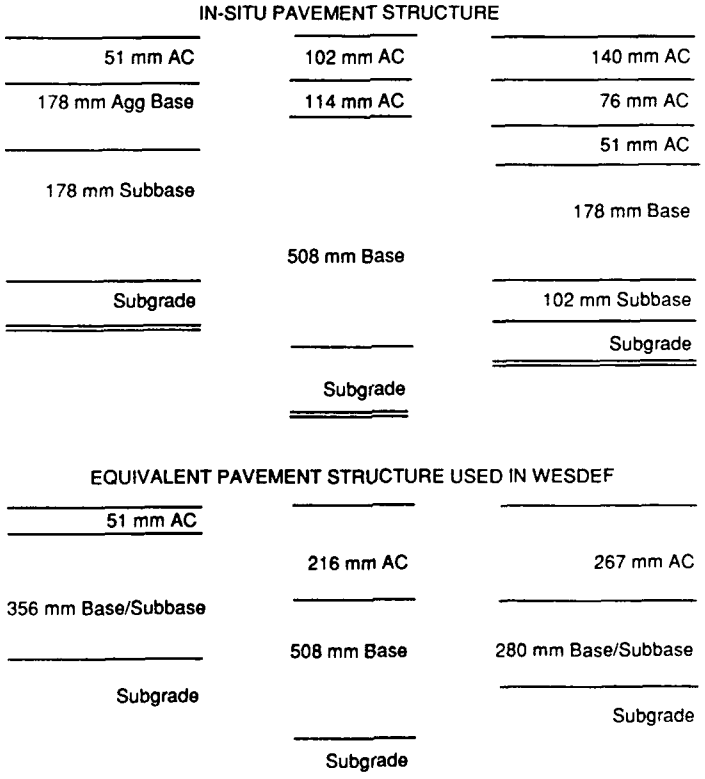


Figure 23. Pavement structure used in WESDEF.

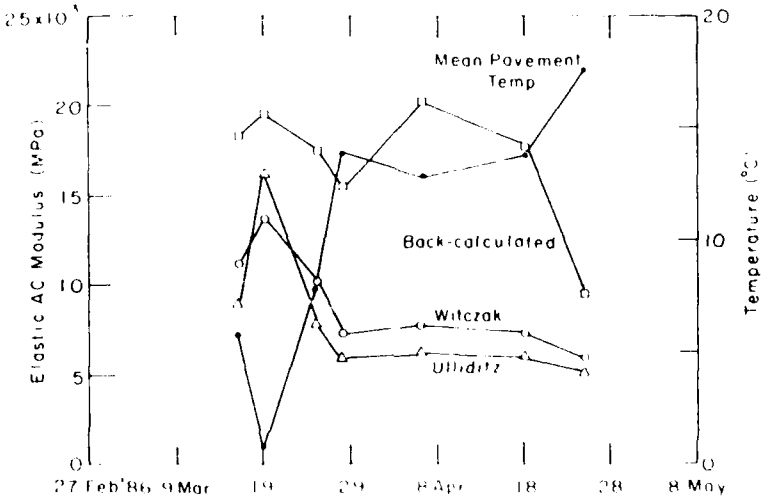
Table 4. Back-calculation analysis using WESDEF.

Date	Elasic modulus (MPa) AC	Base	Subgrade	RMS error (%)
a. FWD point 7, runway 9/27; modulus of all layers calculated.				
16 Mar 86	13,696	602	238	2.9*
19 Mar 86	17,369	370	202	1.5
25 Mar 86	15,063	190	190	0.9
28 Mar 86	13,440	169	165	0.7
06 Apr 86	20,685	97	105	1.2
18 Apr 86	16,748	89	120	1.2
25 Apr 86	9,588	107	119	1.2
b. FWD point 7, runway 9/27; modulus of AC layer fixed, base and subgrade modulus calculated.				
16 Mar 86	11,406	676	235	3.1
19 Mar 86	13,652	480	196	2.2
25 Mar 86	10,503	297	176	2.6
28 Mar 86	7,786	304	151	3.7
06 Apr 86	8,668	403	88	5.0
18 Apr 86	7,594	287	101	4.5
25 Apr 86	6,147	192	109	3.5
c. FWD point 12, runway 9/27; modulus of all layers calculated.				
16 Mar 86	20,547	1034	206	2.1*
19 Mar 86	20,685	1034	159	1.7
25 Mar 86	20,685	608	138	1.3
28 Mar 86	17,143	491	142	1.5
06 Apr 86	13,857	1034	139	1.8
18 Apr 86	11,821	1034	142	1.1
25 Apr 86	7,829	576	153	2.0*
d. FWD point 12, runway 9/27; modulus of AC layer fixed, base and subgrade modulus calculated.				
16 Mar 86	10,735	2069	207	3.3
19 Mar 86	13,672	2069	156	2.4
25 Mar 86	10,268	2069	131	2.4
28 Mar 86	7,851	1992	136	3.1
06 Apr 86	8,330	1923	135	1.5
18 Apr 86	7,787	1680	140	1.7
25 Apr 86	6,681	719	152	2.1
e. FWD point 4, runway 13/31; modulus of all layers calculated.				
16 Mar 86	18,261	215	282	3.0*
19 Mar 86	19,458	131	215	4.2*
25 Mar 86	17,462	69	189	1.6
28 Mar 86	15,408	69	162	1.9*
06 Apr 86	20,151	69	151	0.9
18 Apr 86	17,684	74	158	1.7
25 Apr 86	9,494	96	153	3.3*
f. FWD point 4, runway 13/31; modulus of AC layer fixed, base and subgrade modulus calculated.				
16 Mar 86	11,111	283	275	*
19 Mar 86	13,683	166	209	*
25 Mar 86	10,143	97	175	*
8 Mar 86	7,273	112	151	*
06 Apr 86	7,777	164	134	*
18 Apr 86	7,341	148	145	*
25 Apr 86	5,820	123	149	*

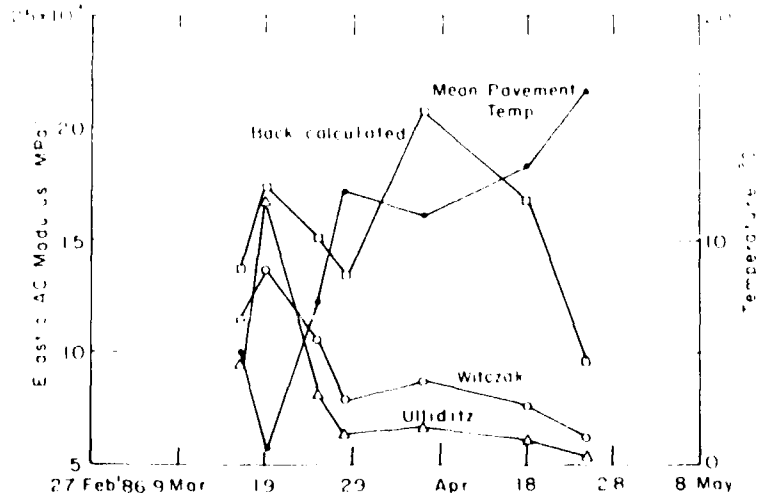
* AA > 10%.

WESDEF was used to back-calculate the layer moduli of the pavement structure at three FWD points—7 and 12 on runway 9/27 and 4 on runway 3/31. The pavement structure used is shown in Figure 23. The structure shown in this figure represents a consolidation of similar layers shown in Figure 2. These sections had a Pavement Condition Index (PCI) in 1989 in the range of 70–80, which is considered to be a good to very good condition. Therefore, any changes seen in the calculated modulus was attributable to the thawing of the pavement.

Our first attempt was to back-calculate the moduli of all the layers. The results from WESDEF for the asphalt layer, base–subbase layer and the subgrade are shown in Figure 24 and are also tabulated in Table 4. In most cases the absolute error was within 10%, which is considered to be a good fit between observed and predicted deflections. Another test for good fit between observed and calculated values is the Root Mean Square (RMS) or the mean of the standard deviation (Irwin et al. 1989). Irwin et al. felt that the RMS was independent

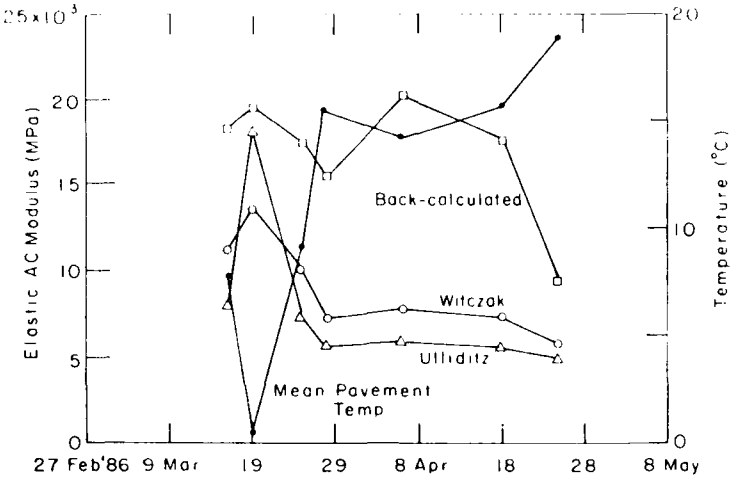


a. FWD point 4, runway 13/31.



b. FWD point 7, runway 9/27.

Figure 24. Calculated AC layer modulus.



c. FWD point 12, runway 9/27.

Figure 24 (cont'd). Calculated AC layer modulus.

of the number of sensors used to characterize the deflection basin, whereas the AA error used in WESDEF was not. An RMS error less than 1% is considered to yield acceptable layer moduli (Table 4).

Even though the fit between observed and calculated values was good, the modulus of the AC layer calculated was much higher than those predicted by methods from either the Asphalt Institute (Witczak Method) (1982) or Ullidtz (1987) (see Fig. 24a), which we used to check our results. The AC modulus determined using Witczak's equation is shown below. The units are English here because Witczak used them to develop his equation.

$$\log E = 5.553833 + 0.028829 \frac{P_{200}}{f^{0.17033}} - 0.03476(V_v)$$

$$+ 0.070377(n_{70°F,\,10^6})$$

$$+ 0.000005\,(t_{p(1.3 + 0.49825 \log f)}\, P_{ac}{}^{0.5})$$

$$- 0.00189\,(t_{p(1.3 + 0.49825 \log f)}) \frac{P_{ac}{}^{0.5}}{f^{1.1}}$$

$$+ 0.931757 \frac{1}{f^{0.02774}}$$

where E = AC dynamic modulus
P_{200} = percent aggregate passing no. 200 sieve
f = frequency
V_v = percent air voids
$n_{70°F,\,10^6}$ = absolute viscosity at 70°F, poise × 10^6
P_{ac} = asphalt content, percent by weight of mix
t_p = pavement temperature (°F).

Based on information obtained from the Wisconsin Department of Transportation, who apparently designs the asphalt mix for airfields in Wisconsin, the following assumptions were used in calculating the modulus of the AC using Witczak's equation:

P_{200} = 5%
V_v = 4% (the acceptable range was 3–5%)
$n_{70°F,\,10^6}$ = 1.0 (Asphalt Institute 1982) (assuming an AC 10 asphalt was used)
P_{ac} = 6% (the acceptable range was 5–7.5%)

The frequency (f) used was 20 Hz. This is the frequency commonly assigned to FWD loading.

The other method for predicting AC modulus was developed by Ullidtz (1987), based on back-analysis of deflection data from the AASHO road test. The AC modulus can be determined from the following equation between the temperature range of 0 and 40°C:

$$E_t = 15{,}000 - 7900 \log(t)$$

where E_t = asphalt concrete modulus (MPa)
and t = pavement temperature (°C).

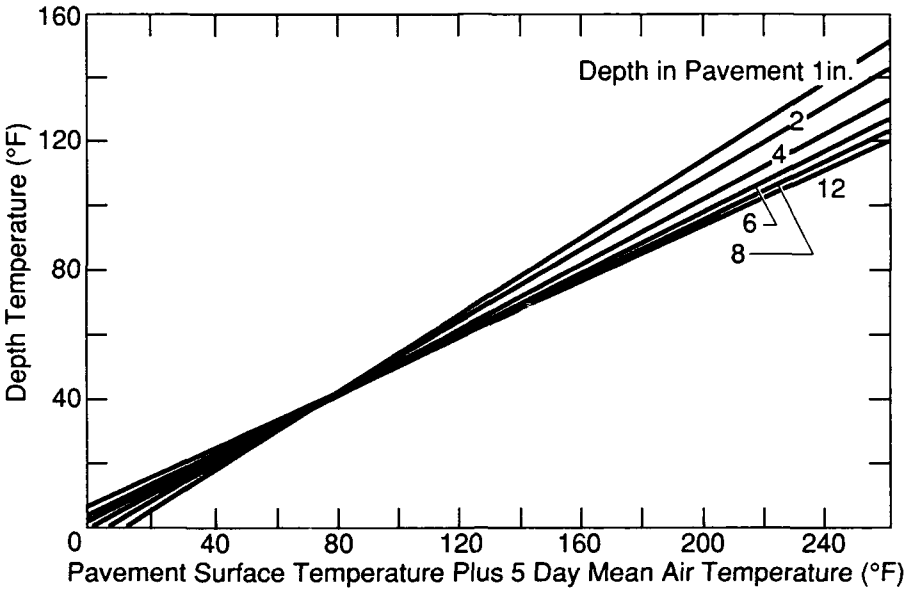


Figure 25. Prediction of pavement temperature for AC layers (after Van Cauwelaert et al. 1989).

The mean pavement temperature (t_p) can be determined using a similar method recommended by the Asphalt Institute (1983)—t_p is determined as a function of the mean air temperature [(daily max + daily min)/2] of the previous 5 days and the pavement surface temperature at the time of the FWD test. The sum of the the surface temperature and the previous 5-day mean air temperature are used in Figure 25 to determine the pavement temperature at mid-depth. This temperature (t_p) was then used in the Witczak or Ullidtz procedure to determine the AC modulus. The procedure for calculating the mean pavement temperature and AC modulus was computerized using LOTUS 123 as follows.

Example for predicting mid-depth pavement temperature

On 25 March 1986 at the time of FWD testing at point 7, the pavement surface temperature was 62°F. The AC layer thickness was 7.5 in.

The method described above requires a knowledge of the previous 5-day mean air temperature. This information can be obtained from weather observation centers. For example, for the Oshkosh area, the minimum and maximum air temperatures for the previous 5 days are tabulated below. The mean air temperature is the average of the minimum and maximum air temperatures.

	Air temperature (°F)		
	Minimum	*Maximum*	*Mean*
20 Mar 86	32	41	36.5
21 Mar 86	4	32	18.0
22 Mar 86	5	20	12.5
23 Mar 86	14	37	25.5
24 Mar 86	32	47	39.5
Sum of the mean air temperature			132.0

The mean 5-day air temperature = 132/5 = 26.4°F.

The sum of the surface pavement temperature and the mean 5-day air temperature = 62 + 26.4 = 88.4°F.

This value, 88.4°F, is entered as the x value in Figure 25, with a mid-depth pavement depth of 3.25 in. (7.5/2) to obtain the mid-depth pavement temperature of 45°F.

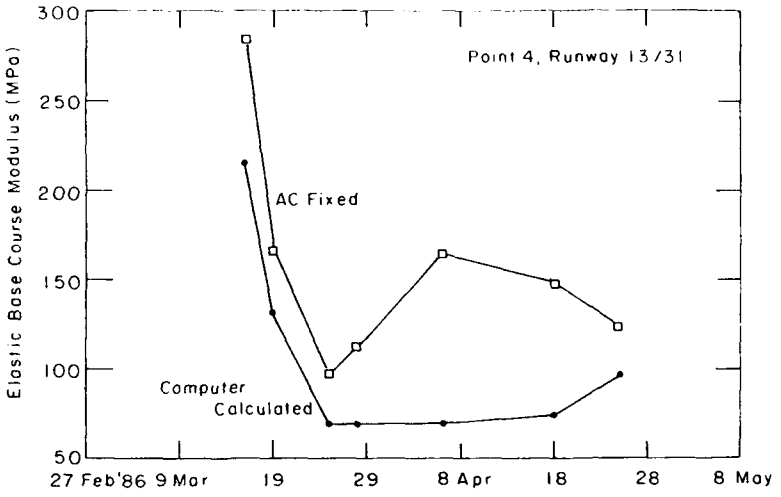
We looked at the effect of setting or fixing the AC modulus on the back-calculated base and subgrade modulus. We used Witzcak's equation for calculating the AC modulus. The results of the back-calculation of the base and subgrade moduli are compared to the three layer results in Figures 26 and 27 and reported in Table 4.

First, when the modulus of the AC layer was fixed, we were unable to meet the AA error of 10% except for two days at point 12 on runway 9/27. In either case, the RMS error in most of the cases were greater than 1%.

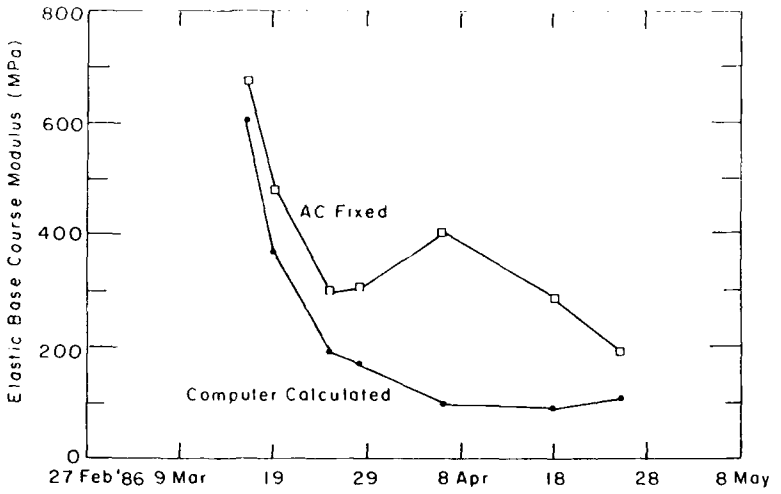
Summary of back-calculation study

Asphalt concrete modulus

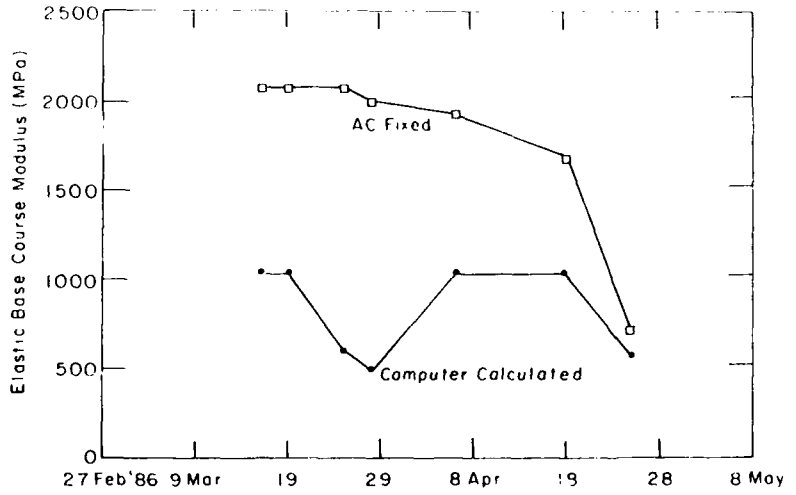
The back-calculated moduli of the AC at the three points were larger than those predicted by either the Witczak or Ullidtz method. However, the error between observed and calculated deflections were within the acceptable range. When we fixed the AC modulus using Witzcak's equation, the error increased. As can be seen



a. FWD point 4, runway 13/31.

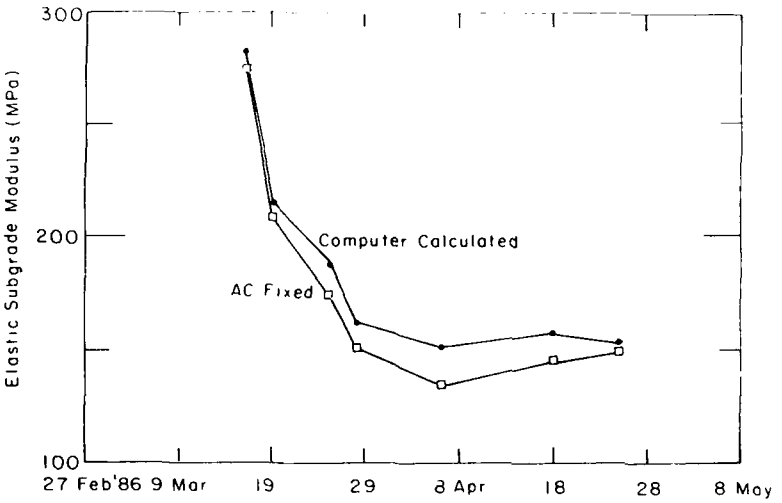


b. FWD point 7, runway 9/27.

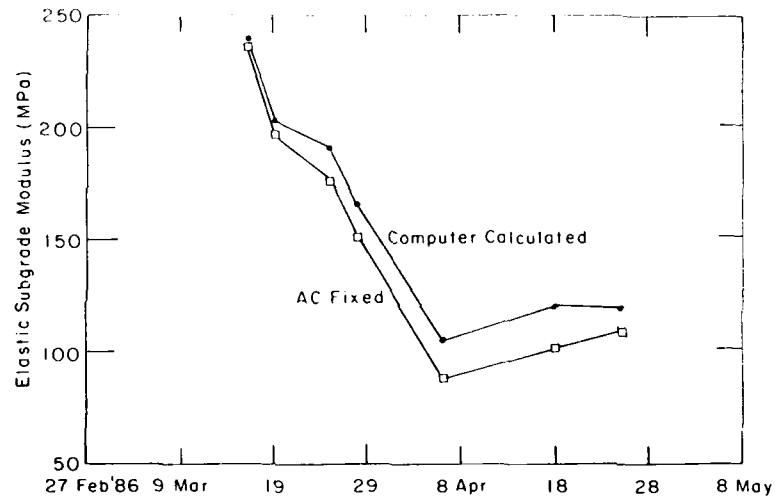


c. FWD point 12, runway 9/27.

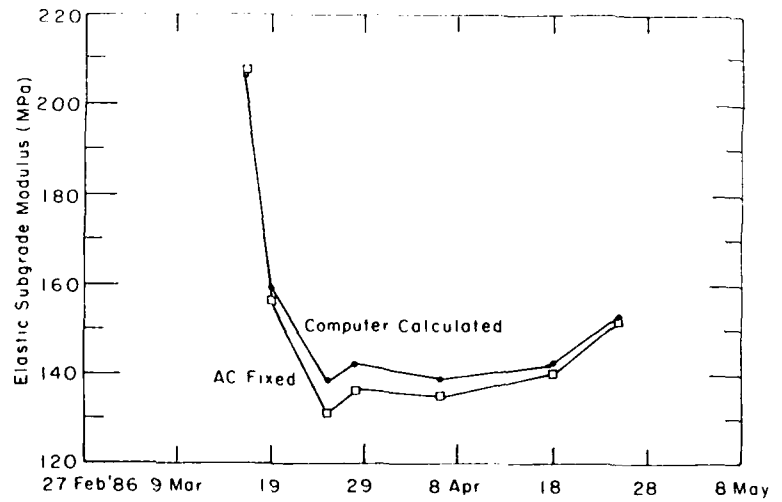
Figure 26. Calculated base course layer moduli.



a. FWD point 4, runway 13/31.

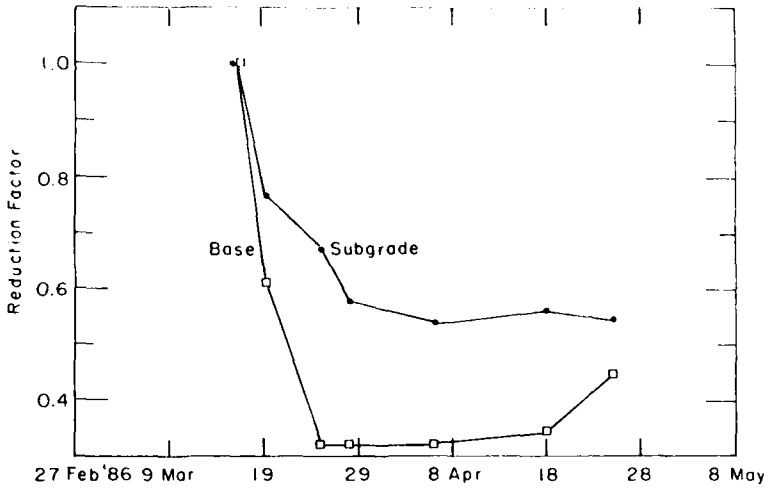


b. FWD point 7, runway 9/27.

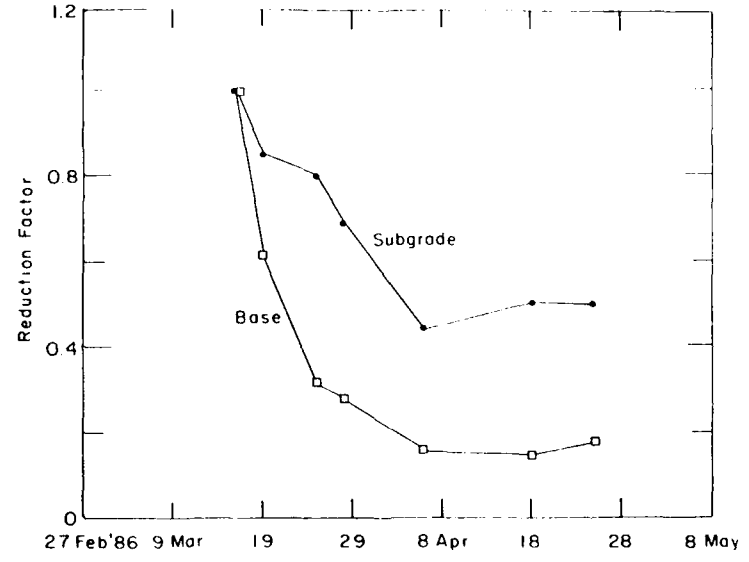


c. FWD point 12, runway 9/27.

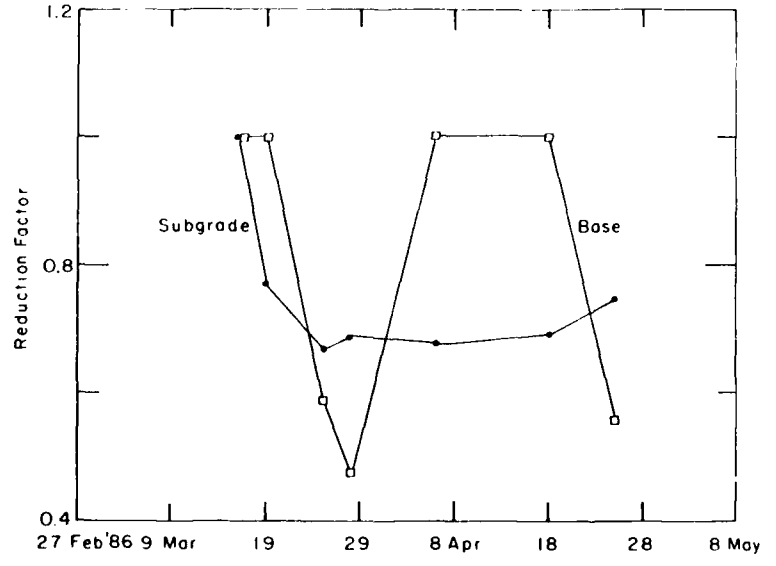
Figure 27. Calculated subgrade layer moduli.



a. FWD point 4, runway 13/31.



b. FWD point 7, runway 9/27.



c. FWD Point 12, runway 9/27.

Figure 28. Percent reduction in modulus for the base and subgrade.

in Figure 24, the AC modulus from Ulliditz method was even lower, except at 0°C, where the back-calculated and predicted modulus match closely.

Base course

The trend at points 7 and 4 show a major reduction in modulus with time. At point 12, on runway 9/27, the modulus of the base course stays fairly constant, suggesting that the spring thaw period has only a slight effect on its response. The modulus values determined from the back-calculation procedure at point 12 seem to be on the high side of typical values of 35 to 1050 MPa. The effect of fixing the AC modulus in the back-calculation procedure has a great effect on the calculated base course modulus. The base course modulus doubles during the early part of thaw.

The modulus back-calculated for the base course at point 4 on runway 13/31 is lower than that of the subgrade. The lower modulus is possible as FWD operators noted that they bailed out water from the the thermocouple and moisture sensor holes near point 4, suggesting a waterlogged base course.

Subgrade

The subgrade modulus back-calculated from the second attempt (fixed AC modulus) is slightly lower than that from the first attempt. The difference is small enough that, for all practical purposes, they are the same. Therefore, we can say that the back-calculated subgrade modulus is not affected by the AC modulus.

The error in the modulus of the AC layer could be attributed to not knowing the heights of the AC, base and subbase layers more accurately. It has been found that determining the layer thickness accurately is extremely important for back-calculating layer moduli (Irwin et al. 1989) because the whole process of back-calculation is very sensitive to layer thicknesses. We found that depending on pavement thicknesses from construction history and even from pavement evaluation reports can lead to errors. It is clear that coring of pavements must be done to gather information on layer thicknesses and should be considered as part of FWD testing. Other errors such as seating errors and random error can be reduced by dropping the FWD weight from the same height at the same point a minimum of four times.

As seen in the back-calculated moduli, the modulus of the base–subbase and subgrade changes during spring thaw, in some cases by 85% for good pavements. The reduction factors with respect to 16 March 1986 for the three points are shown in Figure 28. It can be seen from Figure 28 that the modulus of the base course reduces to a greater extent than the subgrade during the thaw period. However, this reduction of modulus for either the base or subgrade may be lower if taken with respect to the modulus determined during the fall period.

CONCLUSIONS

The deflection basin area is a good indicator of AC pavement response during spring thaw.

The fourth deflection sensor measurements also appear to be a good indicator of the subgrade response.

The study also showed that to understand and characterize pavement response fully, FWD measurements must be made during the summer or fall period.

A relationship similar to that developed by Witczak (Asphalt Institute 1982) for AC modulus should be developed for the spring thaw period. The asphalt moduli back-calculated are much higher than those predicted by either Witczak's or Ullidtz's model.

The modulus from the back-calculation procedure shows large reductions during the spring thaw period. Reduction factors up to 85% for the base course were found. Further studies to clarify this finding are needed. We also found that the rate of reduction of the base course modulus was larger than that of the subgrade modulus. Subgrade modulus reductions of up to 70% were found under good airfield pavements.

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APPENDIX A. FWD MEASUREMENTS

LOC
X — FWD LOCATION
X100 — CENTER OF SLAB
X200 — TRANSVERSE JOINTS
X300 — LONGITUDINAL JOINTS
X400 — CORNER JOINTS

SENSOR LOCATION: 0 300 600 900 1200 1500 1800
PLATE RADIUS: 150 mm
DATE: 16-Mar-86
TEMP: 8.9 C

LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	599	198	124	57	26	16	12	10
1100	598	173	103	45	23	15	12	10
1100	1115	379	224	102	52	33	26	21
1100	1664	505	291	128	70	46	37	30
2100	579	188	124	67	36	21	15	11
2100	586	162	102	53	28	17	13	10
2100	1124	355	230	123	71	42	31	23
2100	1625	463	296	158	91	56	40	31
3100	563	306	235	139	73	36	21	13
3100	551	264	194	111	56	27	16	11
3100	1110	596	450	256	137	69	40	27
3100	1514	780	588	319	172	90	53	37
4100	584	198	148	84	44	24	17	13
4100	565	171	122	67	35	20	15	13
4100	1109	367	264	150	83	46	31	24
4100	1589	474	348	192	109	63	45	35
5100	561	412	271	123	47	18	12	11
5100	543	340	210	86	33	16	13	12
5100	1096	695	429	178	72	36	28	26
5100	1530	826	500	196	84	46	39	34
5200	557	744	31	24	21	18	14	12
5200	536	513	33	27	23	18	15	12
5200	1096	928	71	58	49	40	33	26
5200	1546	1131	93	77	65	53	43	34
6100	561	244	198	136	90	56	36	24
6100	555	229	182	123	81	50	34	22
6100	1106	509	404	275	183	115	78	51
6100	1532	679	541	364	242	152	101	67
14100	571	483	282	131	58	27	16	11
14100	564	415	234	110	52	27	17	11
14100	1119	949	540	260	122	58	32	22
14100	1494	1230	696	338	165	79	44	30
15100	600	148	110	69	45	28	20	15
15100	595	134	96	61	40	27	19	15
15100	1166	305	221	143	95	63	45	33
15100	1645	408	294	190	128	85	61	45

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	16-Mar-86							
TEMP:	8.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
15200	584	197	50	39	33	26	21	17
15200	600	175	50	39	33	25	20	17
15200	1147	380	106	89	72	58	46	36
15200	1685	509	145	118	98	77	62	48
16100	542	597	254	94	40	22	18	14
16100	551	452	187	71	33	21	17	13
16100	1101	904	377	156	78	48	36	29
16100	1569	1031	459	200	107	68	51	40
7100	612	90	73	56	39	27	26	15
7100	606	86	68	49	35	33	20	15
7100	1159	192	155	117	85	63	45	36
7100	1711	260	213	154	116	81	63	51
8100	595	113	90	67	48	34	25	21
8100	587	107	87	61	47	33	26	20
8100	1145	232	189	137	103	73	51	39
8100	1655	311	248	188	135	99	69	53
9100	585	107	85	60	43	32	26	18
9100	580	97	74	57	40	28	20	17
9100	1133	223	177	129	93	65	47	35
9100	1633	296	234	173	125	88	63	47
10100	584	160	122	84	59	37	24	19
10100	580	149	119	76	55	33	24	25
10100	1129	331	250	176	119	78	57	43
10100	1601	431	331	227	156	105	69	50
10200	588	222	42	34	31	28	20	23
10200	602	211	40	32	29	26	22	16
10200	1131	436	88	73	62	48	42	31
10200	1579	571	116	95	78	65	53	43
11100	608	57	46	37	32	24	23	19
11100	604	55	44	34	33	25	20	16
11100	1189	129	95	81	64	50	40	32
11100	1764	167	128	104	87	67	54	42
12100	611	67	56	53	42	38	30	23
12100	597	66	59	49	39	34	27	23
12100	1192	152	129	106	88	72	57	46
12100	1716	211	172	142	119	96	79	60
12200	573	178	42	33	29	26	19	16
12200	570	168	40	34	28	23	19	15
12200	1157	412	86	71	58	46	37	30
12200	1622	567	109	93	74	60	47	39
13100	609	55	43	36	31	30	22	22
13100	602	49	45	36	36	22	23	23
13100	1178	115	93	79	65	52	44	35
13100	1781	158	127	106	86	70	63	45

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	19-Mar-86							
TEMP:	-3.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	598	306	206	106	53	29	17	14
1100	594	278	182	91	45	24	16	13
1100	1206	609	433	203	106	58	38	29
1100	1590	794	787	262	137	76	49	38
2100	607	250	179	106	64	38	26	18
2100	614	227	157	92	52	30	20	16
2100	1244	501	353	206	122	71	46	31
2100	1614	659	471	272	161	94	61	45
3100	595	355	277	172	97	51	28	18
3100	604	335	254	155	86	48	27	16
3100	1193	760	612	372	216	115	64	41
3100	1588	1055	859	501	288	155	86	56
4100	617	225	166	96	54	30	21	17
4100	615	209	151	87	49	28	20	19
4100	1264	473	354	209	117	69	44	32
4100	1687	632	484	282	164	91	69	44
5100	611	462	315	150	68	32	18	20
5100	608	434	286	134	56	25	17	18
5100	1209	946	635	291	115	48	36	39
5100	1581	1257	838	377	149	66	48	49
5200	580	897	62	36	27	25	23	22
5200	592	840	64	37	30	32	27	21
5200	1163	1776	108	70	57	57	47	42
5200	1491	1952	119	81	78	71	63	50
6100	621	307	247	178	119	74	51	31
6100	619	294	239	171	115	71	50	32
6100	1212	685	557	398	267	173	107	71
6100	1628	936	768	541	367	228	148	92
7100	669	109	95	68	51	36	27	24
7100	666	103	87	71	49	34	27	23
7100	1248	226	182	142	108	76	56	47
7100	1737	295	254	188	143	104	80	292
8100	670	131	111	85	64	45	32	26
8100	649	125	102	79	56	40	35	23
8100	1253	275	220	174	127	91	76	48
8100	1752	363	299	235	171	121	86	67
9100	662	126	103	82	59	43	33	25
9100	648	123	98	74	56	42	33	26
9100	1249	260	215	160	119	84	62	50
9100	1729	344	286	216	164	114	84	64
10100	663	169	130	93	65	46	38	27
10100	635	161	120	85	59	44	34	22

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	19-Mar-86							
TEMP:	-3.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1244	986	256	187	134	87	62	47
10100	1710	378	342	245	171	115	81	57
10200	681	256	55	41	34	26	21	18
10200	659	245	48	38	32	27	21	18
10200	1234	510	103	83	69	54	42	36
10200	1690	675	129	104	85	67	55	45
11100	691	78	59	54	40	34	34	21
11100	663	72	58	45	42	32	27	22
11100	1274	149	128	101	87	71	58	53
11100	1852	201	158	132	115	91	73	113
12100	663	92	73	62	59	46	37	33
12100	644	92	70	61	54	44	35	34
12100	1314	181	158	134	116	96	78	65
12100	1822	243	216	181	155	128	104	84
12200	646	198	50	44	35	28	24	20
12200	637	196	53	46	37	33	25	23
12200	1267	452	100	92	71	57	44	37
12200	1720	635	125	105	87	71	57	50
13100	682	68	52	46	41	32	26	22
13100	655	65	52	47	38	35	27	26
13100	1276	85	113	95	81	66	56	46
13100	1799	552	151	137	107	91	75	58
14100	597	774	517	281	145	69	37	26
14100	602	716	474	259	135	67	31	19
14100	1172	1702	1149	631	327	146	66	38
14100	1521	2044	1579	874	452	204	83	48
15100	639	245	191	134	87	53	33	26
15100	627	234	181	123	83	52	34	23
15100	1242	554	439	302	199	123	81	54
15100	1687	764	614	413	272	171	111	76
15200	625	326	55	45	36	29	24	19
15200	653	309	55	46	36	29	31	19
15200	1241	692	128	100	83	62	54	41
15200	1714	930	163	132	107	89	72	55
16100	623	539	325	160	81	41	29	23
16100	620	482	298	141	70	45	33	25
16100	1270	1076	679	345	173	92	61	46
16100	1633	1431	918	465	238	126	88	69

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	19-Mar-86							
TEMP:	0 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	699	71	60	55	46	38	33	27
17100	1018	95	87	82	62	54	42	41
17100	1321	133	121	102	87	76	60	49
17100	1843	178	159	140	123	93	74	67
17200	664	128	82	63	49	38	27	27
17200	1010	187	121	93	71	51	39	31
17200	1330	263	171	138	103	72	56	45
17200	1802	354	232	181	135	95	73	60
17300	748	119	54	49	35	29	24	22
17300	1052	177	81	63	52	42	36	32
17300	1319	253	105	89	71	56	51	37
17300	1824	361	142	112	87	71	61	52
17400	696	299	154	126	101	75	60	40
17400	1001	431	224	181	144	107	77	60
17400	1286	593	318	250	197	147	105	73
17400	1705	781	425	344	265	200	140	100
18100	707	61	53	39	33	25	20	18
18100	1014	90	74	60	47	36	28	25
18100	1322	125	103	81	63	50	41	35
18100	1840	167	139	108	85	66	52	45
18200	728	49	44	37	34	26	21	21
18200	1025	72	65	57	45	38	31	26
18200	1329	101	92	76	66	52	43	36
18200	1857	139	128	103	87	72	59	47
18300	701	93	68	55	44	30	24	19
18300	999	138	102	78	58	43	33	31
18300	1305	190	138	105	81	60	47	40
18300	1813	260	184	138	108	80	60	46
18400	745	92	88	74	61	50	41	33
18400	1018	138	126	109	89	74	61	48
18400	1327	192	181	152	125	100	84	66
18400	1855	268	252	215	180	142	110	90
19100	690	73	66	57	51	40	32	27
19100	1011	108	96	84	70	56	49	35
19100	1316	150	137	117	98	80	62	49
19100	1844	205	183	161	135	108	86	68
19200	684	165	129	102	77	56	44	31
19200	1006	245	191	150	114	84	57	41
19200	1302	335	260	204	157	113	79	59
19200	1794	437	342	270	206	150	106	75
19300	682	121	87	69	50	42	30	23
19300	997	175	131	99	75	58	47	33

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	19-Mar-86							
TEMP:	0 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1306	249	180	136	105	78	59	47
19300	1826	336	241	185	141	103	79	60
19400	683	244	151	121	91	65	48	33
19400	982	344	219	171	130	93	67	46
19400	1297	466	295	231	178	125	90	61
19400	1761	600	382	297	227	163	116	82

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	25-Mar-86							
TEMP:	16.1 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	518	364	247	130	63	32	19	14
1100	518	323	214	108	51	26	17	12
1100	1062	758	504	256	127	64	39	27
1100	1449	967	634	317	163	87	56	41
2100	540	291	214	124	70	36	21	13
2100	542	263	189	108	61	33	20	15
2100	1071	625	454	267	151	82	46	29
2100	1515	812	593	349	202	112	66	43
3100	520	401	310	189	103	51	27	16
3100	520	367	280	167	91	46	26	16
3100	1047	915	708	432	241	122	63	35
3100	1457	1236	1068	582	326	169	88	52
4100	547	272	200	118	64	33	21	15
4100	545	243	176	102	56	30	19	13
4100	1084	575	424	256	143	77	46	32
4100	1506	754	561	342	192	106	63	44
5100	522	503	353	166	69	25	14	11
5100	522	455	311	144	60	25	15	13
5100	1065	1122	781	371	151	55	29	23
5100	1429	1493	1040	488	199	71	39	34
5200	494	1068	111	56	29	20	17	15
5200	510	901	116	58	32	23	21	18
5200	1027	2031	231	111	57	42	39	35
5200	1362	2548	288	136	73	57	53	46
6100	530	346	283	200	132	81	48	30
6100	523	324	264	184	123	75	45	29
6100	1061	788	646	454	308	188	113	70
6100	1489	1065	875	607	414	255	154	95
7100	565	122	99	75	56	39	27	20
7100	545	114	91	69	51	36	27	20
7100	1092	264	217	165	122	86	62	46
7100	1645	355	292	223	166	117	84	62
8100	555	154	125	96	71	50	34	25
8100	553	145	112	87	68	46	32	25
8100	1083	332	276	213	157	110	76	54
8100	1578	437	367	285	214	148	102	73
9100	544	145	117	88	62	45	28	23
9100	540	133	107	80	57	40	27	21
9100	1091	309	254	191	136	95	65	48
9100	1561	403	332	251	183	127	89	64
10100	546	195	153	108	74	47	31	21
10100	539	178	139	97	67	43	29	21

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	25-Mar-86							
TEMP:	16.1 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1086	421	331	233	161	103	67	46
10100	1539	548	431	303	211	136	89	62
10200	550	243	67	51	40	29	22	18
10200	531	220	66	51	40	28	23	17
10200	1090	505	152	115	86	62	46	37
10200	1527	648	213	157	115	81	60	47
11100	560	74	60	51	40	33	26	22
11100	556	73	60	51	41	32	26	21
11100	1103	165	134	111	91	74	57	48
11100	1676	220	175	147	122	98	77	61
12100	562	89	76	66	56	45	37	28
12100	562	86	73	63	52	42	34	26
12100	1112	197	169	146	124	101	81	64
12100	1650	262	225	194	166	136	108	86
12200	543	188	51	42	36	28	22	19
12200	540	178	53	44	37	29	23	19
12200	1096	448	103	86	72	57	45	35
12200	1570	612	135	114	94	76	61	49
13100	561	68	58	49	41	32	26	20
13100	549	68	57	49	40	33	25	20
13100	1111	153	128	108	90	71	57	46
13100	1710	208	171	149	121	96	75	61
14100	524	729	465	238	111	45	17	9
14100	519	648	412	216	104	45	19	11
14100	1054	1662	1083	584	283	111	41	23
14100	1397	2251	1486	812	399	157	54	29
15100	545	267	209	140	89	52	32	22
15100	545	254	198	132	84	50	31	21
15100	1098	632	495	330	210	124	76	50
15100	1537	869	676	454	289	172	103	67
15200	529	365	67	51	39	29	23	18
15200	526	342	68	51	38	28	22	17
15200	1074	835	142	109	83	63	48	39
15200	1477	1133	186	143	110	83	65	52
16100	507	660	375	166	78	40	27	21
16100	512	550	316	144	71	38	25	19
16100	1043	1300	784	376	182	92	59	44
16100	1449	1661	1030	511	251	126	80	59

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	28-Mar-86							
TEMP:	20.6 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	540	384	273	153	85	51	23	35
1100	543	356	252	147	77	41	26	21
1100	1065	854	609	343	189	98	53	36
1100	1505	1157	822	467	251	130	73	45
2100	539	310	227	136	81	45	30	18
2100	540	293	206	126	73	52	30	18
2100	1086	690	504	321	194	106	60	39
2100	1532	928	685	431	262	145	84	53
3100	531	405	309	191	111	59	33	33
3100	528	376	287	184	107	59	32	48
3100	1057	924	713	447	261	139	76	46
3100	1504	1273	979	617	357	198	105	61
4100	542	284	207	122	68	38	24	16
4100	540	268	193	114	64	36	24	17
4100	1090	627	459	277	157	87	52	37
4100	1524	843	621	382	220	123	75	52
5100	514	530	343	160	69	31	18	14
5100	517	483	310	144	64	31	20	15
5100	1055	1169	785	382	172	75	43	32
5100	1434	1570	1066	527	241	106	62	46
5200	509	841	164	91	47	28	21	18
5200	513	729	161	87	46	28	20	16
5200	1044	1731	376	205	105	60	44	35
5200	1424	2269	496	273	141	83	63	50
6100	523	407	339	243	165	101	61	38
6100	518	389	322	230	155	96	58	36
6100	1062	931	778	565	387	243	145	88
6100	1473	1275	1065	772	528	332	201	124
7100	544	132	108	83	63	44	32	23
7100	538	124	100	77	58	42	30	22
7100	1081	290	235	181	135	96	68	50
7100	1579	389	317	244	181	130	93	68
8100	546	170	144	109	79	57	40	28
8100	540	161	133	103	75	53	38	26
8100	1094	375	312	246	182	129	91	63
8100	1562	503	422	329	244	173	120	84
9100	537	153	123	96	70	47	34	22
9100	533	146	116	87	64	45	32	23
9100	1081	332	272	206	152	106	74	53
9100	1599	444	366	280	206	144	100	70
10100	533	214	173	123	87	57	38	26
10100	536	199	159	114	80	53	36	25

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	28-Mar-86							
TEMP:	20.6 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1083	464	372	270	189	125	83	57
10100	1543	630	504	366	256	171	112	77
10200	545	234	142	99	70	48	32	23
10200	526	208	138	97	69	46	31	22
10200	1082	490	322	223	157	104	69	46
10200	1539	642	436	303	213	139	92	65
11100	550	85	70	58	48	39	32	24
11100	549	83	68	57	49	39	31	23
11100	1094	184	149	125	106	86	67	52
11100	1678	244	197	168	142	114	91	71
12100	557	94	79	67	56	45	37	26
12100	553	90	74	63	54	42	33	26
12100	1097	209	174	149	124	100	79	62
12100	1630	278	234	199	167	134	108	82
12200	537	184	88	71	57	44	33	26
12200	537	177	90	74	59	45	34	26
12200	1079	420	203	163	130	99	76	58
12200	1576	565	273	218	172	131	100	76
13100	544	81	70	60	51	40	31	24
13100	542	82	69	60	51	40	32	24
13100	1092	181	153	134	110	89	69	53
13100	1657	245	207	178	151	121	95	73
14100	515	661	413	203	92	38	17	9
14100	510	610	382	192	90	39	17	10
14100	1046	1596	1003	513	235	89	33	21
14100	1367	2207	1409	737	343	126	44	27
15100	532	292	227	152	96	57	35	24
15100	535	278	214	143	91	56	35	24
15100	1102	701	548	369	236	140	84	54
15100	1507	965	757	510	327	196	117	75
15200	507	435	124	92	64	43	29	21
15200	507	405	121	89	62	42	29	22
15200	1059	1037	249	183	128	86	58	43
15200	1444	1418	308	228	159	108	80	57
16100	504	575	330	154	76	42	28	22
16100	504	535	310	147	74	41	28	21
16100	1060	1251	755	372	185	97	62	47
16100	1447	1675	1032	520	261	133	85	63

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	28-Mar-86							
TEMP:	15.0 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	583	99	91	89	73	59	49	44
17100	826	142	131	122	105	91	72	59
17100	1149	195	180	162	142	119	99	77
17100	1632	257	238	212	187	158	129	100
17200	585	110	74	60	52	40	34	26
17200	817	163	114	91	73	58	47	36
17200	1105	235	163	130	104	80	62	48
17200	1619	320	223	179	142	107	81	62
17300	611	154	60	51	51	36	30	23
17300	865	238	92	79	67	54	45	37
17300	1120	345	127	107	87	72	62	48
17300	1709	480	166	136	114	96	76	61
17400	565	206	104	68	52	44	41	29
17400	800	325	174	113	91	71	57	46
17400	1114	469	262	175	139	107	82	64
17400	1598	641	380	262	205	162	121	94
18100	576	60	55	46	39	32	27	23
18100	805	89	78	69	58	48	39	32
18100	1134	129	113	96	81	66	55	43
18100	1640	173	153	127	107	88	69	56
18200	569	60	56	52	47	38	32	28
18200	821	93	85	76	67	60	47	41
18200	1121	130	119	107	97	77	69	52
18200	1636	169	156	140	123	101	83	67
18300	546	103	40	31	28	25	20	17
18300	784	147	59	51	42	36	30	25
18300	1105	206	90	76	63	54	45	37
18300	1598	273	136	112	91	74	62	50
18400	575	86	82	77	61	52	45	35
18400	803	136	124	116	97	81	69	56
18400	1134	190	180	161	138	115	97	79
18400	1649	264	246	222	190	160	133	108
19100	565	107	101	95	84	72	56	43
19100	805	160	150	135	122	101	83	65
19100	1130	222	209	189	167	139	115	90
19100	1608	289	269	244	216	182	150	117
19200	555	116	87	73	55	45	36	24
19200	785	180	138	108	85	64	48	36
19200	1106	254	196	160	122	93	69	52
19200	1604	344	266	217	167	128	97	71
19300	542	141	68	57	48	40	33	25
19300	779	220	104	89	75	61	51	43

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	28-Mar-86							
TEMP:	15.0 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1095	315	148	124	104	86	73	55
19300	1563	426	196	165	143	113	92	72
19400	564	148	88	70	57	43	33	24
19400	806	224	141	112	89	65	51	38
19400	1123	314	200	161	125	97	72	56
19400	1589	417	272	217	170	130	103	78

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	06-Apr-86							
TEMP:	13.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	544	362	276	172	106	65	40	25
1100	533	344	259	164	103	64	38	29
1100	1075	811	623	397	250	152	93	57
1100	1424	1099	845	546	344	210	129	83
2100	552	276	220	146	91	54	33	21
2100	544	262	208	137	87	53	32	21
2100	1105	628	500	335	214	128	77	49
2100	1463	850	679	459	294	178	108	68
3100	544	337	272	176	104	60	37	21
3100	534	322	259	166	101	59	35	22
3100	1084	770	627	402	247	143	84	52
3100	1440	1050	848	551	341	198	118	72
4100	554	243	189	114	67	39	26	18
4100	549	234	181	109	65	38	26	18
4100	1110	544	427	264	159	93	60	41
4100	1450	732	578	363	219	130	84	56
5100	519	442	307	156	77	41	27	21
5100	518	417	287	146	74	41	28	21
5100	1055	984	702	371	191	101	64	47
5100	1425	1323	956	515	268	142	90	66
5200	511	735	184	101	58	37	27	24
5200	508	648	179	99	57	37	27	23
5200	1029	1529	445	248	139	85	61	53
5200	1383	2030	620	346	197	122	87	70
6100	532	330	278	205	143	92	59	37
6100	525	320	269	199	139	90	57	36
6100	1070	767	646	480	337	220	138	87
6100	1455	1048	886	659	463	303	191	123
7100	551	150	133	108	87	67	49	37
7100	546	142	123	102	82	63	49	36
7100	1110	318	279	232	188	145	111	83
7100	1502	419	369	306	248	192	146	108
8100	549	149	128	102	77	56	40	28
8100	550	144	122	96	73	54	38	27
8100	1114	325	273	217	167	121	88	62
8100	1491	433	359	285	220	162	116	82
9100	543	158	135	107	80	58	41	29
9100	536	151	129	101	76	55	40	28
9100	1110	340	286	227	174	126	90	65
9100	1493	448	378	299	230	168	120	85
10100	545	186	153	114	83	57	38	26
10100	547	176	146	108	79	54	38	26

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	06-Apr-86							
TEMP:	13.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1107	396	326	244	178	122	84	58
10100	1477	534	432	323	235	163	112	79
10200	560	132	146	104	74	51	35	24
10200	550	181	143	102	72	50	35	24
10200	1111	407	316	226	162	111	76	52
10200	1467	534	421	300	214	151	100	73
11100	553	75	62	53	44	35	28	22
11100	547	73	61	52	44	35	28	22
11100	1145	165	135	113	96	78	62	48
11100	1513	225	181	153	128	104	83	65
12100	545	89	73	62	52	42	33	26
12100	540	87	72	61	51	41	32	25
12100	1122	198	163	138	116	93	74	58
12100	1524	266	218	185	155	125	100	79
12200	549	150	95	76	59	45	34	26
12200	535	146	94	75	58	45	34	25
12200	1098	343	218	174	137	103	78	60
12200	1496	459	292	233	184	140	106	81
13100	549	79	70	60	50	41	33	26
13100	528	78	69	59	50	41	32	26
13100	1123	175	152	131	112	91	73	59
13100	1494	234	201	176	150	122	99	77
14100	528	513	336	174	86	41	19	26
14100	523	487	314	163	83	38	22	19
14100	1073	1225	824	436	216	93	43	25
14100	1424	1703	1162	634	317	134	59	34
15100	555	252	207	153	95	66	41	28
15100	542	243	198	137	93	58	43	27
15100	1127	598	486	342	228	153	91	61
15100	1480	819	667	472	314	202	126	84
15200	546	377	101	75	55	40	30	23
15200	535	356	102	77	56	42	32	22
15200	1072	901	214	161	121	81	60	49
15200	1432	1234	271	203	152	107	82	71
16100	542	439	304	147	80	45	28	29
16100	544	410	278	140	75	41	30	21
16100	1085	974	675	348	185	100	64	53
16100	1429	1321	924	485	257	140	87	69

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	06-Apr-86							
TEMP:	13.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	566	83	76	69	61	51	43	35
17100	836	128	118	106	94	80	67	55
17100	1138	180	167	151	134	114	96	77
17100	1477	241	223	201	179	152	127	104
17200	550	122	102	83	68	53	41	30
17200	822	191	157	129	105	83	65	50
17200	1131	272	223	184	151	117	91	69
17200	1508	365	296	244	198	155	121	92
17300	557	164	120	99	82	65	50	37
17300	812	251	183	152	125	98	76	56
17300	1109	357	259	214	176	138	107	80
17300	1485	480	343	283	231	183	142	105
17400	538	180	133	109	89	71	57	45
17400	795	278	207	171	141	113	91	72
17400	1082	398	296	246	202	163	131	104
17400	1494	535	397	328	272	220	176	140
18100	536	85	76	69	56	45	37	29
18100	813	132	118	102	87	70	57	45
18100	1111	185	167	143	121	100	81	64
18100	1530	243	218	189	161	132	108	86
18200	548	71	68	61	54	46	38	31
18200	818	110	103	94	82	70	58	47
18200	1130	155	147	133	117	99	84	67
18200	1521	205	194	176	155	131	109	88
18300	525	190	34	29	25	22	19	15
18300	803	292	53	45	40	35	29	24
18300	1095	416	75	66	58	50	43	36
18300	1467	536	103	89	78	66	58	47
18400	523	128	115	102	88	74	60	50
18400	795	186	171	152	132	110	92	74
18400	1085	254	234	208	181	153	126	103
18400	1490	327	300	267	235	200	167	135
19100	541	83	77	68	58	48	38	30
19100	825	127	118	104	90	75	59	47
19100	1123	179	166	148	128	105	85	66
19100	1505	237	218	194	167	139	112	87
19200	539	127	92	74	59	45	33	25
19200	802	193	139	111	88	68	51	38
19200	1096	275	199	162	128	97	75	55
19200	1503	364	266	214	169	129	98	72
19300	537	141	64	51	45	36	27	24
19300	801	213	97	77	66	52	41	35

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	06-Apr-86							
TEMP:	13.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1102	304	136	110	92	72	58	47
19300	1483	404	181	146	120	95	75	62
19400	531	234	121	97	77	59	44	34
19400	785	355	188	152	120	92	69	53
19400	1068	501	271	217	172	131	100	75
19400	1462	662	363	291	230	176	133	100

SENSOR LOCATION:	0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm						
DATE:	08-Apr-86						
AIR TEMP:	10.6 C						

LOC	STRESS (kPa)	DEFLECTIONS (microns)						
1100	570	393	297	180	111	67	43	29
1100	557	375	283	173	106	66	42	28
1100	1125	854	658	407	253	153	96	62
1100	1461	1141	887	555	347	212	132	86
2100	585	299	233	151	95	57	36	26
2100	562	285	223	144	91	55	35	23
2100	1129	646	512	336	214	128	80	50
2100	1475	865	686	457	293	177	110	69
3100	560	355	287	180	112	64	38	28
3100	557	343	275	174	107	61	37	28
3100	1128	797	633	405	251	144	86	168
3100	1448	1076	862	554	343	200	120	76
4100	566	257	199	120	71	42	28	20
4100	562	249	193	117	69	40	28	20
4100	1123	560	439	273	164	97	64	44
4100	1500	751	594	371	223	133	87	60
5100	539	448	317	161	79	42	30	23
5100	533	428	302	154	77	42	30	23
5100	1083	976	715	371	190	102	67	51
5100	1455	1309	957	509	265	142	93	69
5200	530	701	161	95	57	39	30	24
5200	531	657	164	96	57	40	31	25
5200	1081	1470	427	245	142	90	68	54
5200	1392	1930	624	352	201	126	95	73
6100	552	343	287	212	147	94	61	39
6100	543	339	280	207	144	93	61	39
6100	1098	789	658	488	339	221	141	89
6100	1459	1068	891	662	462	300	193	121
7100	602	161	138	113	90	68	50	37
7100	587	155	133	107	86	64	49	36
7100	1124	348	296	244	195	148	112	82
7100	1498	457	388	317	257	196	148	109
8100	588	158	135	106	80	57	42	29
8100	576	152	130	102	77	56	41	30
8100	1130	337	287	225	172	123	88	63
8100	1472	442	379	297	229	165	117	83
9100	583	156	135	105	79	57	40	28
9100	567	151	130	101	76	55	40	28
9100	1121	342	289	227	172	124	89	64
9100	1481	451	380	299	229	166	119	85
10100	583	190	158	117	85	57	40	28
10100	578	181	151	113	81	56	39	28

SENSOR LOCATION:	0	300	600	900	1200	1500	1800	
PLATE RADIUS:	150 mm							
DATE:	08-Apr-86							
AIR TEMP:	10.6 C							
LOC	STRESS (kPa)	DEFLECTIONS (microns)						
10100	1136	399	331	249	180	123	86	60
10100	1477	521	430	323	235	163	112	78
10200	594	193	161	111	79	53	37	26
10200	585	185	157	109	77	53	37	26
10200	1132	400	341	237	168	114	78	54
10200	1513	525	447	312	223	151	104	74
11100	633	81	66	56	48	37	30	24
11100	615	80	65	55	47	37	30	24
11100	1172	178	143	119	100	81	65	50
11100	1540	236	188	157	133	106	85	67
12100	624	88	76	64	54	44	35	27
12100	612	87	75	63	54	43	34	26
12100	1168	198	167	140	119	95	76	60
12100	1525	267	223	186	157	126	100	78
12200	584	164	102	80	62	48	37	28
12200	586	160	101	79	62	47	36	27
12200	1128	363	231	183	143	108	82	62
12200	1483	482	309	244	190	144	110	82
13100	606	87	73	64	55	45	36	27
13100	596	83	72	64	54	44	35	27
13100	1147	185	161	138	118	95	76	61
13100	1507	243	209	181	153	125	100	78
14100	548	540	363	187	90	40	19	11
14100	553	517	347	182	90	42	21	13
14100	1089	1260	866	464	228	99	46	27
14100	1441	1719	1194	653	325	139	60	37
15100	582	268	215	152	100	61	40	27
15100	574	258	209	146	97	61	40	28
15100	1105	622	497	348	230	144	93	61
15100	1452	847	681	476	319	200	127	84
15200	548	422	91	71	53	38	29	22
15200	546	404	95	74	55	38	29	23
15200	1088	957	200	153	113	81	61	47
15200	1427	1298	267	203	150	108	80	63
16100	544	486	311	151	77	44	30	22
16100	543	456	294	143	74	41	28	21
16100	1099	1050	704	353	184	100	65	48
16100	1447	1410	951	492	259	140	90	66

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	08-Apr-86							
TEMP:	10.6 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	652	82	77	69	61	51	43	34
17100	864	127	118	105	92	78	66	53
17100	1185	176	163	148	130	110	93	74
17100	1561	233	214	194	171	145	121	97
17200	626	126	102	83	67	51	40	30
17200	872	197	159	130	104	81	62	47
17200	1139	278	224	183	148	114	88	65
17200	1523	372	297	240	194	150	116	86
17300	623	160	108	88	71	56	43	32
17300	866	245	164	133	108	85	66	50
17300	1130	345	227	185	151	119	92	71
17300	1568	462	297	244	198	155	120	91
17400	602	201	151	121	98	77	61	48
17400	864	306	228	185	151	119	95	75
17400	1120	429	317	261	213	169	134	105
17400	1507	567	422	349	284	224	178	140
18100	616	95	86	73	62	51	42	33
18100	849	145	131	112	95	78	63	49
18100	1122	202	181	156	133	108	87	71
18100	1511	261	235	202	173	141	115	92
18200	603	74	70	64	58	49	41	33
18200	851	114	109	97	88	75	63	51
18200	1131	160	152	136	124	105	88	74
18200	1531	213	200	179	162	137	117	98
18300	566	240	36	31	27	24	21	18
18300	836	358	54	49	42	37	32	26
18300	1120	494	76	67	58	51	44	36
18300	1460	639	99	86	76	65	57	48
18400	611	131	123	110	97	82	67	58
18400	842	207	195	177	154	130	109	90
18400	1126	300	286	254	222	189	159	129
18400	1521	411	389	348	305	259	218	180
19100	612	85	80	72	61	51	42	32
19100	853	131	121	104	95	81	62	51
19100	1116	181	169	142	144	114	87	70
19100	1533	242	222	194	173	141	114	91
19200	581	132	94	78	61	47	36	26
19200	841	205	146	119	94	71	55	39
19200	1118	285	208	168	133	100	77	57
19200	1480	378	278	223	176	133	103	78
19300	587	142	64	54	43	35	27	22
19300	846	214	99	83	67	52	43	33

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	08-Apr-86							
TEMP:	10.5 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1122	301	140	116	95	76	60	48
19300	1472	403	184	151	123	97	78	63
19400	585	206	119	96	77	58	44	32
19400	834	304	181	147	114	87	66	50
19400	553	240	126	101	80	61	47	34
19400	828	356	196	157	124	94	71	53
19400	1105	488	275	220	175	132	100	75
19400	1498	629	365	292	230	176	133	100

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	11-Apr-86							
TEMP:	10.6 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	552	358	272	170	105	69	42	34
1100	550	343	262	166	102	63	46	28
1100	1084	790	603	386	241	151	94	61
1100	1445	1057	809	521	335	202	129	90
2100	569	291	229	148	95	55	36	58
2100	567	284	218	141	89	54	40	24
2100	1116	641	497	328	208	125	81	51
2100	1466	858	664	440	283	171	107	70
3100	557	337	270	177	103	59	40	29
3100	556	325	257	166	100	57	35	24
3100	1084	762	602	391	239	139	87	57
3100	1447	1030	816	533	326	194	115	75
4100	580	251	197	121	74	42	28	32
4100	572	244	190	117	73	42	29	24
4100	1127	548	436	275	174	97	64	51
4100	1471	736	592	373	227	135	90	64
5100	539	438	310	156	79	41	33	26
5100	551	422	290	149	72	48	36	23
5100	1084	945	675	353	184	97	67	50
5100	1451	1264	915	485	251	135	94	72
5200	533	651	162	101	59	40	33	26
5200	529	599	165	98	59	42	35	25
5200	1051	1334	423	247	139	89	69	55
5200	1409	1751	619	354	198	123	93	72
6100	566	332	282	209	142	91	62	38
6100	545	330	276	204	140	90	60	37
6100	1072	758	651	476	333	222	136	86
6100	1456	1032	887	649	454	292	191	126
7100	602	153	132	108	86	68	56	40
7100	591	145	126	103	86	69	53	41
7100	1098	321	278	232	185	140	106	83
7100	1467	415	365	301	244	191	140	106
8100	569	158	138	108	80	61	48	31
8100	563	150	129	106	81	55	47	32
8100	1128	336	285	222	170	121	86	64
8100	1472	443	375	294	230	162	118	81
9100	572	154	138	108	87	57	43	34
9100	560	147	128	103	79	61	39	31
9100	1102	335	290	225	174	124	91	68
9100	1494	437	370	291	223	163	119	84
10100	558	193	161	119	84	63	46	27
10100	541	187	149	112	86	60	44	28

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	11-Apr-86							
TEMP:	10.6 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1125	401	327	245	176	123	82	67
10100	1474	524	432	322	236	158	113	76
10200	576	201	154	114	78	54	37	33
10200	571	191	151	109	75	51	35	26
10200	1133	416	333	234	166	112	83	55
10200	1455	546	436	315	223	151	106	73
11100	596	84	70	59	47	40	33	26
11100	569	82	67	58	49	40	36	25
11100	1141	180	142	121	104	80	65	51
11100	1508	234	187	162	133	107	87	67
12100	594	89	81	64	60	49	36	30
12100	586	87	78	64	56	44	37	35
12100	1140	192	168	143	119	96	75	66
12100	1502	260	222	194	158	127	100	78
12200	587	152	105	85	72	49	39	30
12200	583	153	101	80	67	47	37	28
12200	1110	340	231	183	146	107	84	63
12200	1467	454	316	250	194	145	112	84
13100	586	84	74	71	60	48	38	30
13100	579	87	76	68	54	47	35	34
13100	1089	182	160	139	117	94	84	67
13100	1497	242	212	183	153	125	102	80
14100	527	515	351	176	84	38	23	18
14100	534	492	335	170	85	39	23	13
14100	1066	1213	831	439	216	95	41	26
14100	1435	1674	1157	622	305	130	55	34
15100	557	261	210	147	93	62	38	27
15100	550	250	202	142	97	57	45	31
15100	1073	607	492	335	220	141	87	59
15100	1470	836	668	463	304	190	122	81
15200	536	380	99	76	55	44	34	34
15200	538	360	103	76	61	43	33	22
15200	1058	879	220	162	122	85	65	49
15200	1420	1196	288	214	159	112	93	66
16100	528	467	300	143	74	43	33	32
16100	530	451	294	142	71	41	34	22
16100	1087	1021	671	345	178	96	63	48
16100	1449	1380	917	472	244	139	87	65

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	11-Apr-86							
TEMP:	8.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	706	81	75	68	59	51	46	34
17100	980	123	114	102	90	77	65	52
17100	1204	169	157	147	127	104	88	71
17100	1609	225	210	185	164	138	115	95
17200	622	142	105	85	69	53	42	36
17200	858	213	159	130	107	80	63	51
17200	1164	298	228	184	153	112	87	65
17200	1531	391	297	237	192	147	118	86
17300	602	145	107	88	71	58	44	36
17300	861	222	159	131	109	86	65	51
17300	1146	306	219	181	148	115	92	69
17300	1580	414	287	243	192	149	118	89
17400	565	204	143	115	97	73	60	49
17400	833	308	217	180	142	113	91	70
17400	1111	430	303	247	199	157	125	98
17400	1473	564	400	329	262	208	164	129
18100	594	109	103	88	72	60	49	39
18100	839	167	150	131	109	89	80	58
18100	1127	231	206	182	152	125	105	83
18100	1505	300	266	234	199	166	134	111
18200	637	78	81	70	59	52	44	36
18200	875	125	115	103	92	81	65	55
18200	1139	166	160	143	129	109	92	74
18200	1547	223	209	188	167	143	121	97
18300	591	246	44	36	34	28	28	20
18300	825	359	61	55	48	45	36	30
18300	1133	496	79	71	65	55	46	41
18300	1506	649	101	92	79	69	64	52
18400	583	176	162	147	127	107	89	71
18400	834	267	249	226	195	168	137	112
18400	1105	377	355	316	277	237	197	164
18400	1467	484	459	406	357	304	257	210
19100	611	87	81	74	65	51	46	35
19100	853	135	123	108	93	82	64	48
19100	1118	180	169	150	130	107	87	71
19100	1472	239	219	195	172	139	114	88
19200	592	137	98	80	62	51	36	27
19200	838	206	146	119	93	71	54	42
19200	1113	282	205	165	131	103	75	57
19200	1472	369	276	216	171	131	102	77
19300	636	143	79	58	55	37	30	28
19300	837	207	105	87	71	58	49	38

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	11-Apr-86							
TEMP:	8.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1118	293	151	122	101	83	63	53
19300	1499	389	188	155	126	102	82	69
19400	597	235	123	99	79	59	47	34
19400	828	349	188	153	119	94	69	55
19400	1116	484	267	215	172	129	99	75
19400	1460	633	357	287	228	174	133	100

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	15-Apr-86							
TEMP:	6.1 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	552	349	265	166	106	67	43	29
1100	549	340	254	168	103	64	42	33
1100	1087	769	581	381	238	148	95	71
1100	1446	1026	780	507	328	202	130	89
2100	581	289	229	149	92	58	41	23
2100	569	278	218	148	96	54	36	28
2100	1137	622	488	327	214	127	80	56
2100	1501	834	654	441	289	175	108	72
3100	571	356	283	180	114	62	41	32
3100	571	344	271	172	104	65	41	33
3100	1104	775	622	394	246	140	84	55
3100	1444	1041	869	534	330	193	116	76
4100	598	250	201	124	73	42	30	20
4100	595	241	191	122	70	42	28	20
4100	1138	542	434	278	166	101	67	47
4100	1564	719	579	373	230	135	87	62
5100	549	439	297	152	78	42	30	24
5100	541	420	282	149	74	41	29	23
5100	1095	945	659	348	180	97	66	51
5100	1449	1266	897	482	252	136	89	67
5200	527	706	177	104	63	43	32	27
5200	524	655	175	101	61	41	31	28
5200	1088	1433	447	251	142	92	70	55
5200	1405	1881	634	357	198	125	94	74
6100	596	336	291	211	146	93	59	40
6100	589	330	279	205	145	93	61	43
6100	1092	765	644	474	332	215	137	87
6100	1458	1031	873	643	453	299	189	122
7100	611	150	130	111	84	64	53	36
7100	611	150	123	101	84	62	52	35
7100	1121	312	270	223	182	137	105	78
7100	1513	410	353	290	234	180	142	105
8100	616	149	132	105	82	58	44	35
8100	606	146	126	106	74	57	41	30
8100	1147	319	273	221	167	121	87	62
8100	1501	422	359	288	220	157	115	82
9100	586	153	131	102	77	56	42	28
9100	581	148	128	100	79	59	44	36
9100	1115	322	278	220	168	124	88	64
9100	1514	423	369	287	222	163	118	86
10100	586	181	155	114	82	55	38	27
10100	579	172	146	108	77	58	37	28

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	15-Apr-86							
TEMP:	6.1 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1102	376	326	237	177	119	84	57
10100	1506	492	431	313	226	156	108	78
10200	596	188	152	112	79	54	38	25
10200	592	181	151	107	76	52	36	26
10200	1125	392	324	232	163	110	78	53
10200	1558	513	424	307	219	145	105	71
11100	654	76	65	55	47	39	35	27
11100	637	75	62	54	45	43	32	24
11100	1145	164	139	115	101	83	67	52
11100	1591	220	180	155	130	106	84	68
12100	654	81	71	67	51	44	34	27
12100	643	83	71	62	53	42	36	27
12100	1174	184	157	134	110	93	71	56
12100	1577	246	211	177	151	126	97	77
12200	625	143	103	83	61	50	36	29
12200	620	139	98	80	61	48	40	31
12200	1161	313	222	175	138	103	79	61
12200	1537	418	297	234	184	140	107	81
13100	658	81	71	69	58	43	35	28
13100	639	80	70	66	54	45	35	34
13100	1144	182	154	133	116	95	76	63
13100	1572	241	201	176	150	122	100	76
14100	555	547	368	191	88	49	21	16
14100	558	528	357	189	88	49	21	16
14100	1076	1263	863	457	222	99	49	32
14100	1447	1730	1192	640	314	129	58	38
15100	619	266	215	153	96	61	39	28
15100	590	259	214	143	95	64	44	35
15100	1107	605	487	335	222	139	90	61
15100	1461	828	663	460	305	192	132	83
15200	552	404	102	79	56	41	32	25
15200	552	389	105	82	58	42	32	26
15200	1085	911	223	169	122	95	65	55
15200	1450	1238	294	221	162	115	85	68
16100	556	473	320	154	81	46	32	24
16100	558	447	307	150	81	51	30	28
16100	1105	1012	692	355	183	102	66	56
16100	1463	1356	927	485	260	139	92	68

SENSOR LOCATION:	0	300	600	900	1200	1500	1800	
PLATE RADIUS:	150 mm							
DATE:	15-Apr-86							
TEMP:	8.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	718	93	85	79	71	57	52	41
17100	883	136	136	118	104	88	79	60
17100	1211	198	177	161	143	120	101	86
17100	1606	247	228	204	183	154	133	109
17200	654	129	93	80	68	55	37	29
17200	888	200	150	121	97	77	64	46
17200	1173	285	208	171	138	108	87	65
17200	1562	373	277	225	180	140	110	84
17300	628	158	106	88	71	55	44	37
17300	903	236	150	130	102	87	67	52
17300	1171	325	208	174	140	118	88	68
17300	1598	431	265	225	180	142	120	90
17400	622	185	130	110	86	69	58	42
17400	855	286	206	163	135	104	87	69
17400	1134	396	286	230	188	148	118	93
17400	1498	524	375	311	247	196	154	126
18100	656	88	79	73	68	54	43	36
18100	853	134	117	106	92	76	65	54
18100	1161	179	166	151	130	108	93	75
18100	1572	237	214	190	167	139	115	94
18200	631	81	75	68	62	51	45	34
18200	872	117	113	104	91	81	66	60
18200	1139	164	156	140	125	108	89	74
18200	1578	225	211	186	166	141	120	95
18300	607	185	48	42	37	31	27	27
18300	852	279	68	64	54	45	44	36
18300	1129	394	94	88	73	66	54	52
18300	1518	516	120	108	89	78	70	63
18400	611	158	152	135	113	95	76	66
18400	848	239	224	198	174	140	117	94
18400	1126	333	310	272	238	198	163	137
18400	1502	427	399	352	306	255	215	173
17400	610	178	163	147	124	106	86	71
17400	842	252	235	209	188	158	136	102
17400	1116	340	318	286	246	207	173	139
17400	1496	434	397	352	309	257	217	176
17400	596	171	163	144	129	105	86	74
17400	836	257	239	218	190	157	131	103
17400	1114	343	322	288	250	212	176	141
17400	1492	428	398	353	309	261	218	178
19100	654	110	106	91	79	69	55	46
19100	862	159	150	135	113	96	80	63

SENSOR LOCATION:	0	300	600	900	1200	1500	1800	
PLATE RADIUS:	150 mm							
DATE:	15-Apr-86							
TEMP:	8.9 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19100	1147	222	203	182	158	132	107	86
19100	1558	280	260	233	200	168	140	105
19200	637	121	96	75	56	45	35	27
19200	855	188	135	107	85	67	54	39
19200	1134	258	195	154	126	94	73	56
19200	1534	347	255	207	165	127	96	72
19300	616	136	81	64	53	47	34	35
19300	845	205	114	100	81	62	53	41
19300	1132	289	167	133	112	89	73	55
19300	1530	386	206	176	143	118	91	75
19400	591	205	110	91	69	54	43	30
19400	839	308	168	138	106	83	66	51
19400	1121	437	238	193	151	116	93	67
19400	1497	571	327	263	210	161	121	98

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	18-Apr-86							
TEMP:	18.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	531	395	278	163	97	59	38	24
1100	525	378	267	158	94	57	37	24
1100	1072	848	607	364	221	132	82	53
1100	1438	1131	818	498	308	185	116	73
2100	537	305	229	142	86	50	32	20
2100	535	292	219	137	83	48	31	20
2100	1078	666	499	317	194	113	69	45
2100	1467	890	667	427	264	154	94	59
3100	532	370	286	175	101	57	34	21
3100	525	353	274	167	98	55	33	21
3100	1074	805	618	383	227	127	75	47
3100	1449	1082	834	519	309	174	103	65
4100	539	262	199	115	65	37	25	16
4100	542	251	191	111	63	36	24	17
4100	1094	560	431	259	151	87	56	40
4100	1467	748	575	350	205	118	76	54
5100	525	461	307	143	69	38	28	22
5100	520	436	290	137	67	38	27	22
5100	1068	978	666	326	159	85	60	45
5100	1440	1314	907	452	222	119	81	64
5200	507	661	159	88	52	35	27	23
5200	511	612	160	90	52	35	27	22
5200	1056	1356	437	232	127	81	61	50
5200	1396	1800	623	329	179	112	84	67
6100	542	354	291	206	138	86	53	33
6100	534	344	283	201	135	84	52	33
6100	1067	812	670	478	325	204	127	78
6100	1467	1108	912	652	443	277	171	106
7100	586	156	135	106	83	62	46	34
7100	556	151	128	101	80	59	44	32
7100	1078	335	282	227	178	132	98	71
7100	1497	443	375	303	238	178	132	95
8100	560	169	142	108	80	55	39	27
8100	555	162	135	103	76	53	38	27
8100	1095	361	296	228	171	119	84	59
8100	1495	474	389	300	226	157	111	77
9100	575	164	139	109	80	56	39	27
9100	557	155	132	101	75	52	37	25
9100	1094	343	290	223	168	119	83	58
9100	1504	451	379	296	223	157	111	78
10100	547	200	163	118	81	51	35	24
10100	540	190	155	113	79	50	36	25

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	18-Apr-86							
TEMP:	18.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1075	418	341	249	175	113	77	53
10100	1485	551	449	327	230	152	102	70
10200	548	199	159	111	77	51	34	26
10200	543	189	153	107	75	50	34	24
10200	1090	418	338	235	166	110	73	50
10200	1474	547	444	310	219	145	98	67
11100	581	85	68	55	46	36	28	22
11100	579	85	68	56	46	37	29	21
11100	1083	186	145	119	100	78	62	47
11100	1529	246	192	159	132	104	82	63
12100	588	89	76	64	54	42	34	27
12100	576	86	73	62	50	40	31	23
12100	1090	198	166	139	117	92	72	56
12100	1525	268	220	186	154	121	96	78
12200	556	158	104	81	63	47	35	26
12200	560	152	102	79	61	45	33	25
12200	1083	349	232	182	140	104	78	58
12200	1499	470	311	245	188	139	105	78
13100	566	84	74	63	53	42	33	25
13100	562	83	73	63	52	41	33	25
13100	1107	186	163	138	117	93	75	57
13100	1525	247	215	183	155	123	99	76
14100	530	540	361	176	81	36	17	11
14100	528	512	343	170	80	36	17	11
14100	1058	1223	834	424	198	80	35	21
14100	1404	1673	1151	599	286	114	49	29
15100	535	270	213	141	90	56	35	25
15100	542	260	205	136	87	54	34	24
15100	1063	618	486	327	211	128	82	55
15100	1469	847	666	450	292	178	112	74
15200	520	388	98	73	54	37	28	22
15200	523	367	101	75	54	37	27	21
15200	1056	863	215	159	116	80	59	46
15200	1426	1168	293	216	157	109	79	62
16100	527	475	297	135	68	38	27	20
16100	531	447	284	130	67	37	26	19
16100	1081	1029	649	313	157	85	57	43
16100	1431	1384	880	435	221	119	79	59

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	18-Apr-86							
TEMP:	19.4 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	615	111	104	93	83	70	58	46
17100	844	162	154	137	121	103	86	68
17100	1104	222	209	185	165	140	117	93
17100	1509	284	264	236	210	178	149	119
17200	585	105	95	79	65	51	42	34
17200	835	159	143	119	100	79	63	50
17200	1101	227	203	169	139	110	89	69
17200	1497	308	269	221	183	146	117	92
17300	566	178	110	94	80	67	54	39
17300	806	264	164	138	119	97	80	64
17300	1101	365	222	188	161	131	108	87
17300	1452	480	280	236	201	164	136	108
17400	563	179	134	103	86	68	54	44
17400	788	269	203	161	131	104	85	67
17400	1100	384	289	228	188	149	120	96
17400	1447	522	387	307	252	201	161	130
18100	595	79	73	66	58	51	43	36
18100	829	120	111	100	88	76	66	54
18100	1095	165	154	139	124	106	90	75
18100	1501	221	199	180	161	138	118	97
18200	588	87	85	77	71	59	50	41
18200	825	134	128	115	104	89	75	61
18200	1090	184	176	160	145	123	104	84
18200	1508	242	228	206	187	160	136	108
18300	570	121	81	69	58	48	39	31
18300	824	189	120	102	87	72	59	48
18300	1103	270	165	139	119	98	82	66
18300	1474	364	210	180	153	127	105	85
18400	570	117	106	93	81	68	57	47
18400	816	178	166	142	124	104	88	73
18400	1096	249	230	200	176	148	126	103
18400	1497	334	307	267	233	198	168	137
19100	592	122	115	103	92	77	63	49
19100	842	181	172	155	137	115	95	73
19100	1108	253	236	214	189	158	130	101
19100	1507	335	311	281	248	208	171	133
19200	577	103	86	69	56	43	34	26
19200	829	159	133	106	87	67	52	40
19200	1096	228	187	151	121	94	74	57
19200	1474	305	249	201	161	125	98	75
19300	556	131	88	75	62	51	41	33
19300	811	197	135	113	95	78	62	50

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	18-Apr-86							
TEMP:	19.4 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1101	279	188	158	133	107	87	69
19300	1497	370	246	205	174	140	114	90
19400	555	138	92	76	62	49	38	30
19400	809	212	144	117	97	75	59	46
19400	1088	300	203	167	136	107	84	65
19400	1490	402	275	223	183	144	113	88

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	18-Apr-86							
TEMP:	16.7 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	628	85	78	72	65	53	46	38
17100	606	84	77	71	64	52	49	41
17100	1135	178	165	149	133	111	93	75
17100	1502	231	212	195	167	143	122	98
17200	594	127	102	81	64	52	39	30
17200	582	123	99	78	62	48	38	29
17200	1129	270	210	172	139	110	83	65
17200	1469	352	274	223	179	139	107	80
17300	560	159	97	81	64	50	41	34
17300	552	154	93	77	64	54	39	31
17300	1124	335	198	167	133	105	82	64
17300	1491	444	252	206	173	133	106	81
17400	546	202	137	111	91	72	57	46
17400	545	195	135	109	90	70	59	46
17400	1119	426	298	243	197	154	125	97
17400	1438	551	389	318	258	205	162	127
18100	597	93	82	71	66	50	45	33
18100	580	87	81	69	62	53	41	36
18100	1118	187	168	148	128	104	86	70
18100	1489	242	219	189	164	139	113	89
18200	582	74	71	69	58	50	43	33
18200	591	81	73	70	57	51	45	35
18200	1111	157	149	134	121	103	87	71
18200	1479	206	195	178	156	133	114	92
18300	549	212	43	36	38	26	25	21
18300	535	211	40	36	35	26	25	20
18300	1099	434	84	76	67	55	49	46
18300	1471	564	110	95	82	75	61	63
18400	554	167	157	139	119	100	86	67
18400	550	165	156	137	119	99	82	67
18400	1113	340	326	284	245	205	172	138
18400	1469	438	410	362	309	264	219	178
19100	595	100	92	82	71	61	46	36
19100	585	97	90	80	71	60	46	41
19100	1115	198	186	164	142	117	95	75
19100	1517	259	245	210	184	150	122	96
19200	561	127	89	71	56	43	32	25
19200	558	124	89	70	58	45	38	25
19200	1110	272	193	153	125	93	71	53
19200	1498	353	254	202	161	124	93	70
19300	563	143	66	55	45	37	31	26
19300	550	143	65	55	44	37	29	25

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	18-Apr-86							
TEMP:	16.7 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1096	303	143	118	80	78	65	54
19300	1478	399	183	154	114	100	81	65
19400	547	162	90	74	60	51	38	35
19400	545	155	87	73	58	46	36	28
19400	1104	337	195	161	133	104	84	65
19400	1444	464	266	220	184	145	116	91

SENSOR LOCATION: 0 300 600 900 1200 1500 1800

PLATE RADIUS: 150 mm

DATE: 22-Apr-86

TEMP: 10 C

LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	613	413	295	176	105	64	50	30
1100	620	391	285	169	107	61	43	34
1100	1144	864	641	391	240	155	100	63
1100	1618	1166	874	539	333	201	130	86
2100	589	347	246	158	95	56	36	29
2100	597	333	234	150	91	54	42	25
2100	1157	734	525	340	208	134	78	56
2100	1611	996	721	462	291	179	106	71
3100	574	415	306	184	107	62	43	27
3100	573	387	290	176	103	59	41	33
3100	1138	876	659	402	239	139	85	55
3100	1597	1194	929	551	327	185	111	75
4100	622	305	227	127	76	41	35	30
4100	599	291	212	121	69	42	32	24
4100	1178	632	468	274	160	93	61	48
4100	1672	860	644	377	220	129	85	62
5100	576	504	332	160	79	46	32	28
5100	576	474	314	153	76	45	33	28
5100	1129	1050	720	354	174	94	69	58
5100	1559	1409	969	492	244	131	92	71
5200	556	789	179	106	64	44	42	33
5200	556	724	181	104	62	48	38	28
5200	1108	1533	476	264	142	97	70	64
5200	1472	2008	681	366	198	126	98	78
6100	603	391	315	230	150	96	61	42
6100	588	380	310	221	152	98	59	42
6100	1142	882	725	513	347	218	134	91
6100	1585	1217	990	700	478	297	186	115
7100	645	158	138	112	89	56	51	37
7100	640	154	137	107	85	69	48	38
7100	1191	344	296	245	189	142	107	80
7100	1731	463	400	321	251	181	141	104
8100	619	185	154	115	85	65	40	29
8100	609	179	148	110	82	65	39	32
8100	1191	392	321	254	179	127	96	61
8100	1699	530	425	327	241	169	116	81
9100	614	174	143	109	84	60	42	31
9100	605	166	135	104	80	56	44	34
9100	1178	362	302	232	176	126	92	64
9100	1697	482	400	310	234	167	118	84
10100	608	223	176	126	87	57	38	26
10100	600	211	167	119	84	56	37	28

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	22-Apr-86							
TEMP:	10 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
10100	1187	461	367	264	183	121	81	55
10100	1686	617	489	351	243	163	108	74
10200	660	222	167	116	82	53	35	28
10200	634	205	161	112	77	55	35	25
10200	1188	446	357	247	171	115	76	53
10200	1694	592	475	324	229	150	102	71
11100	627	94	71	63	53	41	36	25
11100	612	92	70	61	52	44	35	28
11100	1229	196	150	132	109	91	68	53
11100	1845	255	198	173	140	116	90	69
12100	608	101	83	71	63	44	41	28
12100	608	96	79	68	56	45	35	28
12100	1225	209	173	147	123	100	76	60
12100	1786	281	230	194	164	130	105	87
12100	597	162	108	86	64	51	37	36
12100	589	156	109	83	68	53	37	32
12100	1210	348	242	189	147	110	83	64
12100	1748	468	328	256	201	145	120	84
13100	647	94	79	70	58	46	36	35
13100	628	92	76	67	55	46	38	35
13100	1211	199	170	146	124	99	81	62
13100	1806	265	225	189	161	132	104	86
14100	578	667	403	193	87	38	21	19
14100	577	626	385	189	87	41	22	19
14100	1114	1471	913	458	209	89	47	29
14100	1482	1989	1263	642	304	116	51	35
15100	597	307	236	156	100	63	41	30
15100	595	293	229	148	98	62	39	28
15100	1152	692	532	352	227	137	87	61
15100	1620	952	745	487	315	194	121	84
15200	576	444	103	78	59	51	31	25
15200	577	420	105	82	58	42	31	33
15200	1117	968	225	172	124	89	68	50
15200	1539	1306	308	228	166	118	88	70
16100	560	612	345	157	75	45	33	30
16100	560	573	332	148	84	49	32	29
16100	1137	1250	740	348	174	97	67	52
16100	1537	1664	1019	483	244	131	90	69

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	22-Apr-86							
TEMP:	11.1 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	623	116	108	100	87	73	62	53
17100	902	163	155	138	123	107	89	72
17100	1212	222	207	188	168	142	124	96
17100	1750	289	264	239	214	185	163	126
17200	618	117	96	80	65	55	49	37
17200	884	183	148	122	107	83	63	50
17200	1194	257	214	173	142	115	89	75
17200	1732	347	281	230	190	148	115	95
17300	686	174	106	90	82	65	58	42
17300	964	263	158	132	113	95	85	64
17300	1211	365	213	183	153	128	107	89
17300	1710	485	271	232	195	161	136	107
17400	611	185	126	103	86	70	56	45
17400	882	280	199	164	134	105	92	66
17400	1171	395	284	237	189	149	119	94
17400	1684	538	383	309	253	199	164	129
18100	608	87	79	75	64	56	50	39
18100	878	133	125	109	101	82	72	58
18100	1177	181	167	151	135	123	97	80
18100	1744	241	218	200	175	151	128	105
18200	612	96	94	85	80	67	56	50
18200	884	146	136	124	115	95	81	65
18200	1176	198	187	173	154	134	115	89
18200	1737	255	239	224	214	170	142	113
18300	592	174	56	55	44	39	36	35
18300	849	265	80	72	63	53	47	39
18300	1137	353	115	99	89	76	65	50
18300	1638	462	151	137	119	104	82	70
18400	624	146	141	121	103	83	73	55
18400	873	222	206	180	151	126	106	87
18400	1175	298	277	246	207	174	151	122
18400	1729	391	358	318	273	228	190	162
19100	610	143	135	123	109	93	76	63
19100	878	207	194	178	159	132	110	91
19100	1209	284	264	244	221	182	150	118
19100	1737	369	344	315	280	234	193	149
19200	594	119	87	73	58	47	41	29
19200	873	184	135	108	89	68	57	42
19200	1175	258	189	153	127	100	79	60
19200	1741	350	257	213	169	133	102	76
19300	603	150	85	76	67	58	43	34
19300	841	230	132	114	97	84	65	52

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	22-Apr-86							
TEMP:	11.1 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1146	324	183	157	135	115	96	78
19300	1666	431	238	202	172	142	119	95
19400	587	179	98	79	64	51	42	33
19400	834	274	157	124	100	77	61	47
19400	1139	379	220	176	143	111	89	68
19400	1638	497	297	242	193	150	116	89

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	25-Apr-86							
TEMP:	18.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
1100	519	446	285	161	90	55	43	29
1100	523	422	277	156	91	54	36	33
1100	1058	956	643	370	215	127	81	58
1100	1512	1279	870	501	298	181	110	72
2100	532	361	250	143	87	53	33	20
2100	535	346	240	142	77	44	28	20
2100	1067	793	556	326	189	106	64	50
2100	1511	1067	753	443	258	145	88	58
3100	526	428	303	173	97	57	36	21
3100	527	409	286	167	88	50	31	23
3100	1050	939	665	386	211	113	68	45
3100	1512	1267	908	523	294	157	98	64
4100	537	324	217	114	58	37	32	20
4100	536	309	207	107	58	36	30	23
4100	1053	687	470	256	137	79	54	40
4100	1516	909	627	344	196	115	73	60
5100	514	536	316	136	60	38	32	24
5100	504	503	300	132	66	37	28	25
5100	1034	1141	699	313	148	78	59	46
5100	1419	1519	948	436	205	112	81	65
5200	507	727	190	99	56	40	30	30
5200	508	671	194	101	59	43	32	31
5200	1031	1483	514	246	125	80	67	51
5200	1396	1945	727	345	173	107	90	68
6100	520	389	308	212	131	80	51	30
6100	516	389	307	209	135	79	55	34
6100	1043	948	751	512	327	196	116	72
6100	1458	1311	1046	708	454	270	156	95
14100	518	610	353	162	71	29	15	9
14100	520	581	341	163	74	33	17	11
14100	1031	1422	856	417	182	68	29	18
14100	1391	1937	1197	601	265	97	39	25
15100	532	302	224	139	87	50	32	22
15100	527	287	213	134	85	50	32	22
15100	1054	712	532	339	209	122	76	51
15100	1507	978	735	475	292	170	105	71
15200	518	423	102	72	52	35	26	20
15200	521	396	107	76	55	37	28	22
15200	1054	978	238	169	119	81	59	46
15200	1428	1323	322	233	162	110	80	62
16100	515	600	305	127	62	36	26	19
16100	512	561	294	124	63	37	27	21

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	25-Apr-86							
TEMP:	18.3 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
16100	1045	1249	680	304	150	81	58	44
16100	1443	1649	928	425	209	111	77	58
7100	540	188	151	112	84	59	42	29
7100	539	183	146	110	83	59	44	31
7100	1058	411	330	252	189	134	96	68
7100	1577	557	450	342	258	183	131	93
8100	538	215	162	114	78	51	34	24
8100	538	204	153	108	73	48	32	23
8100	1073	463	353	253	173	113	76	53
8100	1538	613	465	343	232	150	99	67
9100	540	189	149	108	77	51	35	24
9100	535	181	143	102	73	50	35	24
9100	1049	412	325	238	169	115	78	54
9100	1558	549	432	317	229	154	105	73
10100	529	241	182	121	76	46	30	21
10100	531	229	172	116	74	47	31	23
10100	1054	526	394	265	171	107	69	48
10100	1537	701	528	354	231	142	93	65
10200	535	232	167	111	73	46	30	22
10200	528	219	160	106	71	45	30	22
10200	1068	498	366	246	163	102	67	46
10200	1517	663	486	327	219	138	91	63
11100	545	107	76	60	49	38	29	21
11100	541	105	74	59	48	37	29	21
11100	1099	237	170	137	110	84	64	47
11100	1657	314	226	180	146	111	85	62
12100	546	111	84	68	54	41	31	24
12100	543	110	84	68	55	42	32	25
12100	1078	253	194	156	125	95	72	54
12100	1613	342	262	212	170	130	99	73
12200	536	184	112	84	63	45	33	24
12200	531	179	112	82	62	45	33	24
12200	1074	421	267	200	150	108	78	57
12200	1574	569	358	280	204	145	106	76
13100	547	108	86	70	57	44	35	25
13100	542	106	85	70	57	44	34	25
13100	1091	240	191	159	130	100	76	57
13100	1660	323	257	212	173	133	101	76

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	25-Apr-86							
TEMP:	17.2 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
17100	596	86	80	77	65	54	44	36
17100	856	131	121	110	103	86	67	58
17100	1131	183	168	152	135	117	95	75
17100	1637	235	217	195	172	150	123	96
17200	597	107	97	79	66	54	43	31
17200	838	167	150	122	100	78	61	47
17200	1146	237	212	170	142	116	87	66
17200	1632	317	275	226	184	144	113	86
17300	609	161	93	76	61	50	40	33
17300	862	250	133	110	92	72	62	49
17300	1114	351	181	155	124	98	79	61
17300	1673	472	232	190	163	126	104	77
17400	569	192	132	107	87	70	55	44
17400	830	296	207	169	138	108	86	67
17400	1103	414	292	240	195	153	122	95
17400	1582	548	388	317	259	205	163	128
18100	578	80	72	62	56	44	38	34
18100	815	121	112	92	86	69	59	48
18100	1097	167	151	131	115	96	81	66
18100	1655	219	196	172	150	126	105	86
18200	572	72	71	60	56	47	40	33
18200	802	113	104	93	84	71	59	48
18200	1088	155	145	127	115	97	82	66
18200	1634	205	187	168	150	127	107	87
18300	557	160	50	42	37	31	25	21
18300	783	239	86	72	61	50	43	35
18300	1080	325	124	104	88	72	60	50
18300	1557	457	164	138	117	95	79	65
18400	564	123	111	95	80	67	57	47
18400	796	187	166	142	121	101	86	70
18400	1087	255	236	200	172	145	121	101
18400	1644	330	304	266	228	191	163	133
19100	569	119	109	103	85	71	63	44
19100	820	173	161	144	125	108	84	69
19100	1097	239	226	195	173	146	115	90
19100	1601	297	276	247	215	179	146	118
19200	557	117	92	72	60	45	34	27
19200	802	173	142	108	87	68	53	41
19200	1080	243	193	154	123	95	72	56
19200	1594	323	261	206	165	125	98	76
19300	551	137	76	65	54	49	32	37
19300	785	207	123	101	86	69	60	42

SENSOR LOCATION:		0	300	600	900	1200	1500	1800
PLATE RADIUS:	150 mm							
DATE:	25-Apr-86							
TEMP:	17.2 C							
LOC	LOAD (kPa)	DEFLECTIONS (microns)						
19300	1080	293	175	138	119	94	78	64
19300	1570	382	221	186	155	123	102	80
19400	556	160	106	84	65	55	44	37
19400	780	240	157	126	101	78	68	51
19400	1072	331	221	179	143	114	84	64
19400	1566	427	298	240	197	148	124	88

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12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

It is accepted that in the winter the load-carrying capacity of pavements increases dramatically because of freezing of the pavement structure. This is more striking in asphalt concrete pavements because of the stiffening of the asphalt at low temperatures. In the spring, the pavement structure below the asphalt layer thaws and can become saturated with water from the melting ice lenses, reducing the strength of the base, subbase and subgrade. In the spring of 1986, CRREL conducted Falling Weight Deflectometer (FWD) measurements at an airfield in Wisconsin, which had pavements that were primarily asphalt concrete, to determine the change in the load-bearing capacity of these pavement structures in a seasonal frost area during thaw weakening periods. In addition to FWD measurements, surface and subsurface pavement temperatures were measured at selected sites. This report gives a general description of the airfield and the pavement structure and a comprehensive analysis of the FWD measurements.

14. SUBJECT TERMS

Airfield pavements
Asphalt concrete pavements
Falling Weight Deflectometer
Frost damage

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